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THE ROYAL NATURAL HISTORY

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GAMBIER BOLTON, F.Z.S., AND MANY OTHERS

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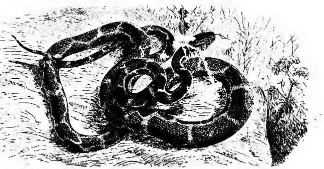


CONTENTS

REPTILES

CHAPTER I.—GENERAL CHARACTERISTICS OF THE CLASS REPTILIA.

PAGE

Differences between Reptiles and other Vertebrates—Diversity of Form and Structure—Skeleton—Teeth—Vertebræ—Classification and Distribution, . . . 1

CHAPTER II.—CROCODILES, DINOSAURS, AND FLYING DRAGONS.—Orders *Crocodilia*, *Dinosauria*, and *Ornithosauria*.

Characteristics of Crocodiles—Their Habits—Existing Crocodiles (*Crocodilidæ*)—Caimans (*Caiman*)—Alligators (*Alligator*)—Double-Tusked Alligators (*Diplocynodon*)—Stumpy Crocodiles (*Osteolæmus*)—True Crocodiles (*Crocodilus*)—Indian Crocodile—Estuarine Crocodile—Nile Crocodile—Siam Crocodile—Sharp-Nosed Crocodile—Orinoco Crocodile—Long-Nosed Crocodile—Schlegel's Gavial (*Rhynchosuchus*)—Gavial (*Garialis*)—Extinct Gavial—The Earlier Crocodiles—The Extinct Dinosaurs (*Dinosauria*)—Flying Dragons, or Pterodactyles (*Ornithosauria*), . . . 10

CHAPTER III.—TORTOISES, TURTLES, AND PLESIOSAURS.—Orders *Chelonia* and *Sauropterygia*.

Characteristics of Tortoises and Turtles (*Chelonia*)—Their Habits and Distribution—The Land-Tortoises and Terrapins (*Testudinidæ*)—Land-Tortoises (*Testudo*)—Florida Tortoise—Brazilian Tortoise—Burmese Brown Tortoise—Elegant Tortoise—Giant Tortoises—Aldabra Tortoise—Mascarene Tortoises—Galapagos Tortoises—Grecian Tortoise—Other Species—Angulated Tortoise—Areolated Tortoise (*Homopus*)—Hinged Tortoises (*Cinixys*)—Spider Tortoise (*Pyxis*)—Spinose Land-Terrapin (*Geoemyda*)—Chaibassa Terrapin (*Nicoria*)—Hinged Terrapins (*Cyclemys*)—Box Tortoises (*Cistudo*)—Pond Tortoises (*Emys*)—Terrapens—Sculptured Terrapin (*Clemmys*)—Thick-Necked Terrapin (*Bellia*)—Hamilton's Terrapin (*Damonia*)—Soft-Water Terrapin (*Malacoclemmys*)—Painted Terrapin (*Chrysemys*)—Eyed and Chinese Terrapins (*Morenia*)—

PAGE

Batagurs (*Cachuga*, etc.)—Big-Headed Tortoise (*Platysternidæ*)—Mud-Terrapins and their Allies (*Cinosternidæ* and *Dermatemydidæ*)—Maw's Terrapin (*Dermatemys*)—The Snappers and Alligator-Terrapins (*Chelydridæ*)—Alligator-Terrapin (*Chelydra*)—Temminck's Snapper (*Macroclemmys*)—The Turtles (*Chelonidæ*)—Green and Hawks-bill Turtles (*Chelone*)—Loggerhead Turtle (*Thalassochelys*)—Habits of Turtles—Tortoise-Shell—Extinct Turtles—Leathery Turtles (*Dermochelyidæ*)—The Side-Necked Tortoises (*Chelyidæ* and *Pelomedusidæ*)—Matamata Tortoise (*Chelys*)—Snake-Necked Tortoises (*Hydromedusa*)—Australian Long-Necked Tortoises (*Chelodina*)—Other Genera—Greaved Tortoises (*Podocnemis*)—Allied Genera—Fly River Turtle (*Carettochelyidæ*)—Australian Horned Tortoises (*Miolanidæ*)—Extinct European Genera—Generalised Chelonians (*Pleurosternum*, etc.)—The Soft-Tortoises (*Trionychidæ*)—Typical Genus (*Trionyx*)—Granulated Soft-Tortoises (*Emyda*, etc.)—Habits of the Group—The Plesiosaurs, or Long-Necked Marine Lizards (Order *Sauropterygia*), . 42

CHAPTER IV.—SCALED REPTILES—LIZARDS AND CHAMÆLEONS,—Order *Squamata*; Suborders, *Lacertilia* and *Rhiptoglossa*.

Characteristics of the Order—Skull—Ribs and Vertebræ—Other Characters—Special Characters of Lizards (Suborder *Lacertilia*)—Numbers and Distribution—Habits—The Geckos (*Geckonidæ*)—Lobe-Footed Gecko (*Ptyodactylus*)—Turkish Gecko (*Hemidactylus*)—Fringed Gecko—Wall-Gecko—Habits of the Group—Eyelid Geckos—The Scale-Footed Lizards (*Pygopodidæ*)—The Agamoid Lizards (*Agamidæ*)—Flying-Lizards (*Draco*)—Oriental Tree-Lizards (*Calotes*)—Ceylon Horned Lizards (*Ceratophora*)—Typical Group (*Agama*)—Armed Agama—Spinose Agama—Rough-Tailed Agama—Australian Frilled Lizard (*Chlamydosaurus*)—Sail-Tailed Lizard (*Lophurus*)—Thorny-Tailed Lizards (*Uromastix*)—Habits—East African Thorny-Tailed Lizards (*Aporoscelis*)—Moloch Lizard (*Moloch*)—The Iguanoid Lizards (*Iguanidæ*)—Anolis Lizards (*Anolis*)—Allied Genera—Basilisks (*Basiliscus*)—Ridge-Headed Lizards (*Corythophanes*)—Stilted Lizards (*Uraniscodon*)—The Sea-Lizard (*Amblyrhynchus*)—Galapagos Land-Lizard (*Conolophus*)—True Iguanas (*Iguana*)—Ring-Tailed Iguana (*Cyclura*)—Extinct Iguanas—Horned Lizards (*Phrynosoma*)—The Girdled Lizards (*Zonuridæ*)—Girdle-Tailed Lizard (*Zonurus*)—The Snake-Like Lizards (*Anguidæ*)—Scheltopusiks (*Ophisaurus*)—Blind-Worm (*Anguis*)—The Poisonous Lizards (*Helodermatidæ*)—The Monitors (*Varanidæ*)—Their Habits—The Greaved Lizards (*Teiidæ*)—The Teju (*Tupinambis*)—The Ameivas (*Ameiva*)—The Amphisbænas (*Amphisbænidæ*)—Handed Amphisbæna (*Chirotes*)—Typical Amphisbænas (*Amphisbæna*)—The True Lizards (*Lacertidæ*)—Pearly Lizard (*Lacerta*)—Green Lizard—Sand-Lizard—Viviparous Lizard—Wall-Lizard—Keeled Lizards (*Algiroides*)—Fringe-Toed Lizards (*Acanthodactylus*)—The Skink Tribe (*Scincidæ*)—Stump-Tailed Lizard (*Trachysaurus*)—Snake-Eyed Lizards (*Ablepharus*)—True Skinks (*Scincus*)—Bronze Lizards (*Chalcides*)—Other Families (*Anelytropidæ* and *Dibamidæ*)—The Chamæleons (Suborder *Rhiptoglossa*)—Their Habits, ... 104

CHAPTER V.—SCALED REPTILES,—*continued*. THE SNAKES—Suborder *Ophidia*.

Distinctive Characters and Structure—Teeth—Harmless and Poisonous Snakes—Distribution—Habits—The Blind Snakes (*Typhlopodidæ* and *Glauconiidæ*)—The Pythons and Boas (*Boidæ*)—True Pythons (*Python*)—Their Distribution and Habits—The Various Species—Allied Genera (*Loxocemus*, *Nardoa*, etc.)—Tree-Boas (*Epicrates*)—Dog-Headed Tree-Boa (*Corallus*)—Keeled Tree-Boas (*Enygrus*)—Anaconda (*Eunectes*)—True Boas (*Boa*)—Keel-Scaled Boa (*Casarea*)—Sand-Snakes (*Eryx*)—Allied Genera (*Lichanura*, etc.)—Extinct Python-Like Snakes (*Palæophis*)—The Cylinder-Snakes (*Ilysiidæ*)—Coral Cylinder-Snake (*Ilysia*)—Red Snake (*Cylindrophis*)—The Shield-Tails (*Uropeltidæ*)—The Colubrine Snakes (*Colubridæ*)—Wart-Snakes (*Acrochordus*)—Water-Snakes (*Tropidonotus*)—Ringed Snake—Tesselated and Viperine Snakes—Oblique-Eyed Snakes (*Helicops*)—Pigmy Snakes (*Calamaria*)—Sling-Snakes (*Coronella*)—Fierce Snakes (*Zamenis*)—Horseshoe Snake—Rat-Snake—Running Snakes (*Ptyas*)—Climbing Snakes

PAGE

(*Coluber*)—Black-Marked Snake—Wood-Snakes (*Herpetodryas*)—Tree-Snakes (*Dendrophis* and *Dendrelaphis*)—Egg-Eating Snake (*Dasypeltis*)—Moon-Snakes (*Scytale*)—Cat-Snake (*Tarbophis*)—Nocturnal Tree-Snakes (*Dipsas*)—Back-Fanged Tree-Snakes (*Philodryas* and *Dryophis*)—Sharp-Nosed Snakes (*Oxybelis*)—Oriental Fresh-Water Snakes (*Homalopsinæ*)—Coral-Snake (*Elaps*)—Resplendent Adders (*Callophis*)—Long-Glanded Snakes (*Adeniophis*)—Craits (*Bungarus*)—Cobras (*Naia*)—Their Habits—Death-Adders (*Pseudechis*)—Sea-Snakes (*Hydrophiinæ*)—Broad-Tailed Sea-Snakes (*Platurus*)—Parti-Coloured Sea-Snake (*Hydrus*)—Black-Banded Sea-Snake (*Distira*)—The Vipers (*Viperidæ*)—True Vipers (*Viperinæ*)—Common Viper (*Vipera*)—Southern Viper—Long-Nosed Viper—Russell's Viper—Puff-Adder—Horned Vipers (*Cerastes*)—Desert Saw-Vipers (*Echis*)—Rattle-Snakes (*Crotalinæ*)—Common Rattle-Snake (*Crotalus*)—Diamond Rattle-Snake—South American Rattle-Snakes—Habits of Rattle-Snakes—The Bushmaster (*Lachesis*)—Halys Vipers (*Ancistrodon*)—Himalayan Halys Siberian Halys—Copper-Head Snake—Water-Viper—Typical Pit-Vipers (*Trimeresaurus*)—Jararaca—Extinct Groups of Scaled Reptiles—Long-Necked Lizards (*Dolichosauria*)—Cretaceous Sea-Serpents (*Pythonomorpha*), ... 174

CHAPTER VI.—THE REMAINING GROUPS OF REPTILES,—Orders *Ichthyopterygia*, *Rhynchocephalia*, and *Anomodontia*.

The Fish-Lizards (Order *Ichthyopterygia*)—The Beaked Lizards (Order *Rhynchocephalia*)—The Tuatera (*Sphenodon*)—Allied Extinct Families (*Homæosauridæ* and *Rhynchosauridæ*)—Oldest Types (*Proterosaurus*, etc.)—The Anomodonts, or Mammal-Like Reptiles (Order *Anomodontia*)—Dicynodonts and Theriodonts, ... 250

AMPHIBIANS

CHAPTER I.—GENERAL CHARACTERISTICS OF THE CLASS AMPHIBIA—FROGS AND TOADS—Order *Ecaudata*.

DISTINCTION BETWEEN AMPHIBIANS AND REPTILES—Skin of Amphibians—Skeleton—Soft Parts—Development—Distribution—Habits—Characteristics of Frogs and Toads—The Typical Frogs (*Ranidæ*)—Water-Frogs (*Rana*)—European Frogs—Bull-Frogs—*Oxyglossus*—Flying Frogs (*Rhacophorus*)—Solid-Chested Tree-Frogs (*Dendrobatidæ*)—The Narrow-Mouthed Frogs (*Engystomatidæ*)—Sharp-Nosed Frog (*Ceratobatrachidæ*)—The Southern Frogs (*Leptodactylidæ*)—Horned Frogs (*Ceratophrys*)—Leaf-Frogs (*Hylodes*)—Piping-Frogs (*Leptodactylus*)—The Toads (*Bufonidæ*)—True Toads (*Bufo*)—Green Toad—Natterjack Toad—Sharp-Nosed Toad (*Rhinophrynus*)—The Overlapping-Chested Tree-Frogs (*Hylidæ*)—Grasshopper-Frog (*Acris*)—Typical Tree-Frogs (*Hyla*)—Their Nesting-Habits—Pouched Tree-Frogs (*Nototrema*)—Pouched Tree-Frogs (*Pelobatidæ*)—Brown Toad-Frog (*Pelobates*)—Other Genera (*Pelodytes*, etc.)—Allied Extinct Frogs (*Palæobatrachidæ*)—The Disc-Tongued Frogs (*Discoglossidæ*)—Fire-Bellied Frog (*Bombinator*)—Midwife-Frogs (*Alytes*)—Other Families (*Amphignathodontidæ* and *Hemiphractidæ*)—The Tongueless Frogs (*Xenopodidæ* and *Pipidæ*)—Spur-Toed Frogs (*Xenopus*)—Surinam Water-Toad (*Pipa*), ... 257

CHAPTER II.—NEWTS, SALAMANDERS, AND CŒCILIANS,—Orders *Caudata* and *Apoda*.

Distinctive Characters of the Caudata—Their Distribution and Habits—The Salamander Tribe (*Salamandridæ*)—Typical Salamanders (*Salamandra*)—Alpine Salamander—Spanish Salamander (*Chioglossa*)—Newts (*Molge*)—Crested Newt—Marbled Newt—Alpine Newt—Common Newt—Webbed Newt—Other Species—Habits of Newts—Spectacled Salamander (*Salamandrina*)—Other Genera (*Tylototriton* and *Pachytriton*)—Axolotls (*Amblystoma*)—Other Genera—The Fish-Like Salamanders (*Amphiumidæ*)—Giant Salamander (*Megalobatrachus*)—Hell-Bender (*Cryptobranchus*)—Three-Toed

PAGE

Salamander (*Amphiuma*)—The Gilled Salamanders (*Proteidæ*)—Olm (*Proteus*)—Furrowed Salamander (*Necturus*)—Two-Legged Salamanders (*Sirenidæ*)—The Cæcilians, or Worm Like Amphibians (Order *Apoda*). 289

CHAPTER III.—The Primeval Salamanders,—Order *Labyrinthodontia*.

Characters and Distribution of the Group—The Leading Families and Genera, . . . 311

FISHES

CHAPTER I.—General Characteristics of the Class Pisces.

Classification—External Skeleton—Internal Skeleton—Teeth—Coloration—Soft Parts—Reproduction—Tenacity of Life—Distribution, ... 314

CHAPTER II.—Lung-Fishes and Chimæroids,—Subclasses *Dipnoi* and *Holocephali*

Existing Lung-Fishes (*Lepidosirenidæ*)—Australian Lung-Fish (*Ceratodus*)—South American Mud-Fish (*Lepidosiren*)—African Mud-Fish (*Protopterus*)—Extinct Lung-Fishes—Berry-Bone Fishes (Order *Arthrodira*)—The Chimæroids (Subclass *Holocephali*), . . . 325

CHAPTER III.—The Bony Fishes and Ganoids,—Subclass *Teleostomi*.

Classification—Fan-Finned Group (Order *Actinopterygii*)—Spine-Finned Fishes (Suborder *Acanthopterygii*)—The Perch Tribe (*Percidæ*)—True Perches (*Perca*)—Pike-Perches (*Lucioperca*)—Danubian Perches (*Aspro*)—Ruffes (*Acerina*)—*Centrarchidæ*—Bass and Sea-Perches (*Serranidæ*)—South American Perch and Bass (*Percichthys* and *Morone*)—Sea-Perch (*Centropristes*, *Serranus*, etc.)—Stone-Bass (*Polyprion*)—Oriental and African Perches (*Lates* and *Psammoperca*)—Scaly-Finned Fishes (*Chætodontidæ*)—*Chætodon*—*Chelmon*—*Heniochus*—*Holacanthus*—Red Mullets (*Mullidæ*)—Sea-Breams (*Sparidæ*)—*Cantharus*—*Haplodactylus*—*Sargus*—Gilt-Heads (*Chrysophrys*)—Knife-Jawed Fishes (*Hoplognathidæ*)—Thick-Rayed Fishes (*Cirrhitidæ*)—*Cirrhitichthys*—*Chilodactylus*—Scorpænoids (*Scorpænidæ*)—Allied Families—Berycoids, or Slime-Heads (*Berycidæ*)—*Curtidæ* and *Polynemidæ*—Sciænoids (*Sciænidæ*)—Drum (*Pogonias*)—Umbrines (*Umbrina*)—Meagres (*Sciæna*)—Sword-Fishes (*Xiphiidæ*)—Scabbard-Fishes and Hair-Tails (*Trichiuridæ*)—Scabbard-Fish (*Lepidopus*)—Hair-Tails (*Trichiurus*)—Barracudas (*Thyrsites*)—Extinct Forms—Surgeons (*Acronuridæ*)—Horse-Mackerels (*Carangidæ*)—Typical Group (*Caranx*)—Pilot-Fish (*Naucrates*)—Sea-Bats (*Platax*)—Dories (*Cyttidæ*)—Stromateids and Coryphænas (*Stromateidæ* and *Coryphænidæ*)—*Coryphæna*—Sun-Fish (*Lampris*)—Nomæids (*Nomæidæ*)—Mackerels (*Scomberidæ*)—Thunnies (*Thynnus*)—Sucking-Fishes (*Echeneis*)—Star-Gazers and Weavers (*Trachinidæ*)—*Uranoscopus*—*Trachinus*—Tile-Fish (*Lopholatilus*)—Other Groups—Soft-Spines and Frog-Fishes (*Malacanthidæ* and *Batrachidæ*)—*Batrachus*—Angler-Fish and their Allies (*Lophiidæ*)—Anglers (*Lophius*)—Tentacle-Fish (*Antennarius*)—Bull-Heads and Gurnards (*Cottidæ*—Bull-Heads (*Cottus*)—Gurnards (*Trigla*)—Beaked Gurnards (*Peristethus*)—Flying Gurnards (*Dactylopterus*)—Dragon-Fishes (*Pegasus*)—Lump-Suckers (*Cyclopteridæ*)—Gobies and Mud-Skippers (*Gobiidæ*)—*Gobius*—*Periophthalmus*—Band-Fishes (*Cepolidæ*)—Hairy-Backs (*Trichonotidæ*)—*Chiridæ*—Blennies (*Blenniidæ*)—Viviparous Blennies (*Zoarces*)—Wolf-Fishes (*Anarrhichas*)—Oblique-Spined Blenny (*Acanthoclinidæ*)—Spiny Eels (*Rhynchobdellidæ*)—Oil-Fish (*Comephorus*)—Barracuda-Pikes (*Sphyrænidæ*)—Sand-Smelts (*Atherinidæ*)—Square-Tail (*Tetragonurus*)—Grey Mullets (*Mugilidæ*)—Gar-Pike and Flying-Fish (*Scombresocidæ*)—Gar-Pike (*Belone*)—Flying-Fish (*Exocœtus*)—Sticklebacks (*Gastrosteidæ*)—Flute-Mouths (*Aulostomatidæ*)—Trumpet-Fish (*Centriscidæ*)—Sucker-Fishes (*Gobiesocidæ*)—Serpent-Heads (*Ophiocephalidæ*)—Labyrinth-Gilled Fishes (*Anabantidæ* and *Luciocephalidæ*)—Climbing-Perch (*Anabas*)—Paradise-Fish (*Polyacanthus*)—Gurami (*Osphromenus*)—Fighting-Fish (*Betta*)—Unicorn-Fish

PAGE

(*Lophotidæ*)—Ribbon-Fish (*Trachypteridæ*)—Thornbacks (*Notacanthidæ*)—*Pomacentridæ* —Wrasses (*Labridæ*)—True Wrasses (*Labrus*)—Parrot-Wrasses (*Scarus*)—Viviparous Wrasses (*Ditrematidæ*)—Chromids (*Chromididæ*)—Tuft-Gilled Fishes (Suborder *Lophobranchii*)—Mailed Tube-Mouths (*Solenostomatidæ*)—Pipe-Fishes and Sea-Horses (*Syngnathidæ*)—Comb-Gilled Group (Suborder *Plectognathi*)—File-Fishes and Coffer-Fishes (*Balistidæ*)—Globe-Fishes and Sun-Fishes (*Diodontidæ*)—Soft-Finned Fishes (Suborder *Anacanthini*)—*Lycodidæ*—The Cod Tribe (*Gadidæ*)—True Cod (*Gadus*)—Haddock—Other Species—Hakes (*Merluccius*)—Burbot (*Lota*)—Ling and Rockling (*Molva*)—Sand-Eels and their Allies (*Ophidiidæ*)—Cave-Fish (*Lucifuga*)—Snake-Fishes (*Ophidium*)—Parasitic Fish (*Fierasfer*)—Sand Eels (*Ammodytes*)—*Congrodus*—The Long-Tails (*Macruridæ*)—Flat-Fishes (*Pleuronectidæ*)—*Psettodes*—Halibut (*Hippoglossus*)—Turbot, etc. (*Rhombus*)—Plaice and Flounder (*Pleuronectes*)—Soles (*Solea*)—Blind Soles (*Soleotalpa*)—The Tube-Bladdered Fishes (Suborder *Physostomi*)—Eel Tribe (*Murænidæ*)—Murænas (*Muræna*)—True Eels (*Anguilla*)—Congers (*Conger*)—Serpent-Eels (*Ophichthys*)—Deep-Sea Eels (*Synaphobranchus*)—Single-Slit Eels (*Symbranchidæ*)—Electric Eel (*Gymnotidæ*)—Cat-Fishes (*Siluridæ*)—Eel-Like Cat-Fish (*Clarias*)—Wels (*Silurus*)—Yarrell's Cat-Fish (*Bagarius*)—Electric Cat-Fishes (*Malapterurus*)—Mailed Cat-Fishes (*Callichthys*, etc.)—Carp Tribe (*Cyprinidæ*)—True Carp (*Cyprinus*)—Crucian and Golden Carp (*Carassius*)—Barbels (*Barbus*)—Gudgeon (*Gobio*)—White-Fish (*Leuciscus*)—Tench (*Tinca*)—Beaked Carp (*Chondrostoma*)—Bitterling (*Rhodeus*)—Bream (*Abramis*)—Rapfen (*Aspius*)—Bleak (*Alburnus*)—Sichel (*Pelecus*) Loaches (*Cobitis*, etc.)—African Loaches (*Kneriidæ*)—Characinoid Fishes (*Erythrinidæ*) Cyprinodonts (*Cyprinodontidæ*)—Double-Eyes (*Anableps*)—Blind-Fish (*Amblyopsidæ*) Umbres (*Umbridæ*)—Pike (*Esocidæ*)—African Beaked-Fish (*Mormyridæ*)—Feather-Backs (*Notopteridæ*)—Southern Pikelets (*Galaxiidæ*)—Arapaimas (*Osteoglossidæ*)—Arapaima (*Arapaima*)—Barbelled Arapaima (*Osteoglossum*)—Small-Mouthed Arapaima (*Heterotis*)—Moon-Eye (*Hyodontidæ*)—Chisel-Jaw (*Pantodontidæ*)—Beaked Salmon (*Gonorhynchidæ*)—The Scopeloids (*Scopelidæ*)—Phosphorescent Scopeloids (*Sternoptychidæ* and *Stomatidæ*)—Silvery Light-Fish (*Photichthys*)—Hedgehog-Mouths (*Echiostoma*)—The Dorab (*Chirocentridæ*)—Long-Finned Herring (*Bathythrissidæ*)—The Extinct Saurodonts (*Enchodontidæ*, *Saurocephalidæ*, etc.)—The Herring Tribe (*Clupeidæ*) —Typical Group (*Clupea*)—Fresh-Water Herrings (*Diplomystus*)—Anchovies (*Engraulis*) —*Elops*—Slender-Scales (*Leptolepis*)—The Smooth-Heads (*Alepocephalidæ*)—Southern Salmon (*Haplochitonidæ*)—Salmon Tribe (*Salmonidæ*)—Typical Group (*Salmo*)—Salmon—Trout—Charr—Many-Rayed Salmon (*Oncorhynchus*)—Smelts (*Osmerus*)—Coregonoids (*Coregonus*)—Grayling (*Thymallus*)—*Percopsidæ*—Bony Pike and its Kindred (Suborder *Ætheospondyli*)—Existing Types (*Lepidosteidæ*)—Spear-Beaks (*Aspidorhynchidæ*)—The Bow-Fin and its Allies (Suborder *Protospondyli*)—Existing Family (*Amiidæ*)—Extinct Families (*Pachycormidæ*, etc.)—The Sturgeon Tribe (Suborder *Chondrostei*)—Toothed Sturgeons (*Polyodontidæ*)—Toothless Sturgeons—(*Acipenseridæ*)—True Sturgeons (*Acipenser*)—Shovel-Beaked Sturgeons (*Scaphirhynchus*)—Allied Extinct Families (*Chondrosteidæ*, etc.)—Fringe-Finned Ganoids (Order *Crossopterygii*)—Existing Species (*Polypteridæ*)—Extinct Families, ... 333

CHAPTER IV.—SHARKS AND RAYS,—Subclass *Elasmobranchii.*

Distinctive Features—The Blue Shark and its Allies (*Carchariidæ*)—Typical Genus (*Carcharias*)—Tope (*Galeus*)—Hammerheads (*Sphyrna*)—Hounds (*Mustelus*)—Porbeagle Group (*Lamnidæ*)—Porbeagles (*Lamna*)—Rondeleti's Shark (*Carcharodon*)—Fox-Shark (*Alopecias*)—Basking-Shark (*Cetorhinus*)—Indo-Pacific Basking-Shark (*Rhinodontidæ*) —Dog-Fishes and Their Allies (*Scylliidæ*)—True Dog-Fishes (*Scyllium*)—Other Genera—Pavement-Toothed Sharks (*Cestraciontidæ*)—Comb-Toothed Sharks (*Notidanidæ*)—Typical Genus (*Notidanus*)—Frill-Gilled Shark (*Chlamydoselachus*)—The Spiny Dog-Fishes and their Allies (*Spinacidæ*) The Extinct Petalodonts (*Petalodontidæ*)—The Angel-Fish (*Squatinidæ*)—The Saw-Fishes (*Pristiophoridæ* and *Pristidæ*)—

PAGE
Side-Gilled Saw-Fishes (*Pristiophorus*)—True Saw-Fishes (*Pristis*)—Beaked Rays (*Rhinobatidæ*)—Typical Genus (*Rhinobatus*)—*Rhynchobatus*—The True Rays, or Skates (*Raiidæ*)—Electric Rays (*Torpedinidæ*)—The Eagle-Rays (*Myliobatidæ*)—Typical Genus (*Myliobatis*)—Other Genera (*Aetobatis*, etc.)—Sting Rays (*Trygonidæ*)—Lobe-Finned Sharks (*Ichthyotomi*)—Fold-Finned Sharks (*Cladodontia*)—Spine-Finned Sharks (*Acanthodii*), ... 520

THE LOWEST VERTEBRATES AND THEIR ALLIES

CHAPTER I.—THE LAMPREY GROUP,—Class *Cyclostomata*.

CHARACTERS OF CHORDATES AND NON-CHORDATES—Lampreys and Hag-Fishes (Subclass *Marsipobranchii*)—True Lampreys (*Petromyzon*)—Southern Lampreys (*Mordacia*, etc.)—Hag-Fishes (*Myxinidæ*)—Primeval Lampreys (*Palæospondylus*), . . . 549

CHAPTER II.—THE ARMOURED PRIMEVAL VERTEBRATES,—Subclass *Ostracophori*.

Pteraspis—*Cephalaspis*—*Pterichthys*, ... 555

CHAPTER III.—THE LANCELETS,—Subkingdom *Protochordata*—Class *Leptocardii*.

Common Lancelets (*Branchiostoma*), ... 558

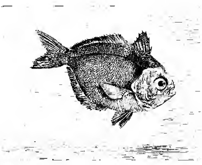
CHAPTER IV.—THE SEA-SQUIRTS OR ASCIDIANS,—Class *Tunicata*.

Structure of Ascidians—Development—Typical Ascidians—Non-Luminous Pelagic Ascidians—Tailed Ascidians, ... 561

CHAPTER V.—WORM-LIKE PROTOCHORDATES,—Class *Enteropneusta*.

Balanoglossus—Other Forms—Ancestry of Chordates, ... 573

INDEX 577



LIST OF ILLUSTRATIONS

COLOURED PLATES

RAT-SNAKE AND COBRAS, . . . *Frontispiece*
SOFT RIVER-TORTOISES, . . . *Facing page* 99
THE BLACK IGUANA, . . . „ 128
WATER-MONITORS ROBBING A NEST, . . . „ 152
WALL LIZARDS, . . . „ 163
CHAMÆLEONS, . . . „ 172
CHIMÆRA, . . . „ 332
GURNARDS, . . . „ 383
GLOBE-FISH AND COFFER-FISH, . . . „ 428
FLAT-FISH, . . . „ 441
A SALMON LEAP, . . . „ 496
BLUE SHARK, . . . „ 522

PAGE PLATES

BLACK CAIMANS AT HOME, . . . *Page* 11
GIANT TORTOISES OF THE GALAPAGOS ISLANDS, . . . „ 54
ROUGH-TAILED AGAMA BASKING, . . . „ 105
A FAMILY OF VIPERS, . . . „ 231
GROUP OF SCALY-FINNED FISHES, . . . „ 342
GIANT AND COMMON STURGEONS, . . . „ 541
ASCIDIANS, . . . *Facing* „ 549

TEXT ENGRAVINGS

REPTILES

PAGE
Mississippi Alligator, . . . 1
Skull of Crocodile, . . . 2
Pelvis of Dinosaur, . . . 3
Skeleton of Ichthyosaur, . . . 4
Skeleton of Armoured Dinosaur, . . . 4
Tooth of Plesiosaur, . . . 5
Skull of Cyamodus, . . . 5
Skull of Flying Dragon, . . . 5
Vertebra of Dinosaur, . . . 6
Vertebra of Fish-Lizard, . . . 8
PAGE
Vertebra of Snake, . . . 6
Skeleton of Crocodile, . . . 10
Skull of Extinct Crocodile, . . . 13
Spectacled Caiman, . . . 16
Mississippi Alligator, . . . 19
Stumpy Crocodile, . . . 21
Estuarine Crocodile, . . . 23
Nile Crocodile, . . . 24
Sharp-Nosed Crocodile, . . . 26
Long-Nosed Crocodile, . . . 28

PAGE
Gangetic Gavial, 30
Restoration of the Iguanodon, 33
Vertebra of Dinosaur, 34
Tooth of Hoplosaur, 34
Tooth of Pelorosaur, 35
Hind-Foot of Dinosaur, 35
Huckle-Bone and Tibia of Megalosaur, 36
Skeleton of Claosaur, 36
Tooth of Iguanodon, 37
Teeth of Trachodon, 37
Toe-Bone of Armoured Dinosaur, 37
Skull of Horned Dinosaur, 38
Restored Skeleton of Horned Dinosaur, 39
Skeleton of Pterodactyle, 40
Restoration of Long-Tailed Pterodactyle, 41
Shells of Chaibassa Terrapin, 42
Skull of Gangetic Soft-Tortoise, 43
Skeleton of Tortoise, 44
Diagram of Plates on Shell of a Tortoise, 45
Plastron of Chaibassa Terrapin, 47
Skull of Tortoise, 47
Brazilian Tortoise, 49
Shell of Burmese Brown Tortoise, 51
Elegant Tortoise, 52
Elephant-Tortoise, 56
Grecian Tortoise, 60
Areolated Tortoise, 62
Dentated Hinged Tortoise, 63
Bell's Hinged Tortoise, 64
Chaibassa Terrapin, 66
Carolina Box-Tortoise, 87
European Pond-Tortoise, 69
Sculptured Terrapin, 71
Carapace of Hamilton's Terrapin, 72
Painted Terrapin, 73
Carapace of Smith's Batagur, 74
Skull of Big-Headed Tortoise, 75
Big-Headed Tortoise, 76
Pennsylvanian Mud-Terrapin, 77
Alligator-Terrapin, 79
Green Turtle, 82
Hawksbill Turtles Swimming, 83
Young Loggerhead Turtle, 84
Leathery Turtle, 87
Humerus of Extinct Leathery Turtle, 88
Skull and Jaw of Greaved Tortoise, 89
Front of Plastron of Side-Necked Tortoise, 89
Carapace of Black Sternothere, 90
Matamata Tortoise, 91
Snake-Necked Tortoise, 92
American Side-Necked Tortoise, 93
Giant Amazonian Tortoise, 94
Skull of Horned Tortoise, 97

PAGE
Carapace of Wide-Shielded Wealden Tortoise, 98
Cantor's Soft-Tortoise, 100
Skeleton of Plesiosaur, 102
Skull of Simosaur, 102
Vertebra of a Plesiosaurian, 103
Skeleton of Lariosaur, 103
Vertebra of a Snake, 104
Skeleton of Lizard, 108
Lobe-Footed Gecko, 111
Turkish Gecko, 112
Fringed Gecko, 113
Wall-Geckos, 115
Common Scale-Footed Lizard, 117
Armed Agama, 121
Sail-Tailed Lizard, 124
Arabian Thorny-Tailed Lizard, 125
Moloch Lizard, 128
Red-Throated Anolis, 130
Helmeted Basilisk, 133
Stilted Lizard, 135
Galapagos Sea-Lizard, 136
Galapagos Land-Lizard, 138
Ring-Tailed Iguana, 141
Horned Lizard, 142
Cape Girdle-Tailed Lizard, 144
Common Scheltopusik, 146
The Blind-Worm, 147
Arizona Poisonous Lizard, 149
Cape Monitor, 151
The Teju, 154
Surinam Ameiva, 155
Handed Amphisbæna, 157
Spotted Amphisbæna, 158
Green Lizards, 161
Viviparous Lizard, 163
Algerian Keeled Lizards, 164
Common Fringe-Toed Lizards, 165
Stump-Tailed Lizards, 167
European Snake-Eyed Lizard, 168
Common Skink, 169
Three-Toed Bronze Lizard, 171
Head of Snake, 175
Skeleton of Snake, 176
Indian Python crushing its Prey, 181
African Python swallowing a Bird, 183
Australian Diamond-Snake, 185
Streaked Tree-Boa, 187
Dog-Headed Tree-Boa, 188
The Home of the Anaconda, 190
Common Boa, 192
Egyptian Sand-Snake, 194
Coral Cylinder-Snake, 196
A Shield-Tailed Snake, 197

PAGE
Javan Wart-Snake, 199
Ringed Snake seizing its Prey, 201
Viperine and Tessolated Snakes, 202
Keel-Tailed Snake, 203
Javan Pigmy Snake, 204
The Dark Green Snake, 206
Black-Marked and Horseshoe Snakes, 208
Æsculapian Snake, 210
Leopard-Snake, 211
The Four-Rayed Snake, 212
Sipo, or Brazilian Wood-Snake, 213
Crowned Moon-Snake, 215
Cat-Snake, 216
Coral-Snake, 219
Long-Glanded Snake and Masked Adder, 220
Banded Adder, or Raj-Samp, 221
Young Giant Cobra, or Hamadryad, 223
Short Death-Adder and Spine-Tailed Death-Adder, 225
Banded Sea-Snake, 227
Black-Banded Sea-Snake, 228
Long-Nosed, or Sand-Viper, 233

PAGE
Russell's Viper, 234
The Puff-Adder, 235
Horned Vipers in the Sand, 236
The Eja, or Desert Saw-Viper, 237
Common Rattle-Snake, 239
Diamond and South American Rattle-Snakes, 241
The Bushmaster, 242
Siberian Halys Viper, 244
Copper-Head, or Moccasin-Snake, 245
Climbing Pit-Viper, 246
Rat-Tailed Pit-Viper, 247
Skeleton of Fish-Lizard containing Young, 251
Paddle of Fish-Lizard, 251
New Zealand Tuatara, 253
Skull of *Hyperodapedon*, 254
Pelvis and Shoulder-Girdle of an Anomodont, 255
Skull of Pavement-Toothed Anomodont, 256
Skull of Wall-Toothed Anomodont, 256
Skull and Teeth of Galesaur, 256

AMPHIBIANS

PAGE
Fire-Bellied Frogs, 257
Bull-Frogs Disporting, 259
Skeleton of Salamander, 260
Skeleton of Frog, 261
Development of the Frog, 262
Moor-Frogs, 264
Agile Frogs, 267
Javan Flying Frog, 269
Variable Tree-Frogs, 270
East African Short-Headed Frogs, 272
Solomon Island Sharp-Nosed Frog, 274
Argentine Horned Frogs, or Escuerzos, 275
Mexican Sharp-Nosed Toad, 278
Grasshopper-Frogs, 279
European Tree-Frogs, 281
Male Midwife Frog, with Chains of Eggs, 285
Smooth Spur-Toed Frog and its Tadpole 287
Female Surinam Water-Toad, 288

PAGE
Alpine Newts, 289
Spotted Salamander, 292
Alpine Salamander, 293
Male and Female of Marbled Newt, 295
Male and Female of Common Newt, 297
Spectacled Salamander, 299
Larval Stage of Mexican Axolotl, 300
Adult of Mexican Axolotl, 301
Giant Salamander, 303
Hell-Bender, or Mississippi Salamander, 305
Three-Toed, or Eel-Like Salamander, 306
The Olm, 307
Siren Salamander, 309
A Worm-Like Amphibian, 310
Skeletons of Primeval Salamanders, 311
Skull of Mastodonsaur, 312
Vertebræ of Primeval Salamander 312
Skull of Metoposaur, 313

FISHES

PAGE
Flying Fish, 314
Skeleton of Perch, 316
Skeleton of Extinct Fringe-Finned Shark, 317
Skeleton of Sturgeon, 318
Skeleton of Fin of Fringe-Finned Shark, 319
Skull of Australian Lung-Fish, 325
Palatal Teeth of Extinct Lung-Fish, 326
Australian Lung-Fish, 327

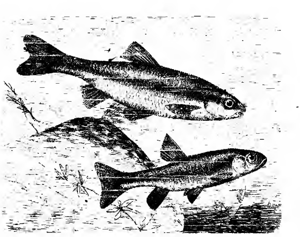
PAGE
South-American Mud-Fish, 328
African Mud-Fish, 329
Restoration of Berry-Bone Fish, 331
Pike-Perch and Common Perch, 334
Danubian Perches and Ruffe, 337
Common Bass, Sea-Perch, and Stone-Bass, 339
Striped Red Mullet, 345
Sargo and Gilt-Head, 347

	PAGE
Australian Knife-Jawed Fish	348
Spotted Firm-Fin	349
Australian Long-Fin	350
Bleeker's Plesiops	352
Schomburgk's Many-Spine	353
Group of Spine-Finned Fishes	354
New Zealand Trachichthys	355
Common Meagre	357
Spotted Indian Sword-Fish	359
Scabbard-Fish	361
Common Mackerel and Horse-Mackerel	364
Pilot-Fish	365
Coryphæna	368
New Zealand Gastrochisma	370
Sucking-Fishes	372
Star-Gazer and Weaver	374
Tile-Fish	376
Hœdt's Soft-Spine	377
Barracuda and Angler-Fish	379
Common Bull-Heads	381
Sapphirine Gurnards	383
Armed Bull Head	384
Beaked Gurnard	385
Australian Dragon-Fish	386
Lump-Sucker and Viviparous Blenny	387
Fresh-Water Goby	388
Mud-Skippers Disporting	390
New Zealand Thorny-Nose	392
Japanese Chirus	393
Oblique-Spined Blenny	395
Indian Spiny Eel and Oil-Fish	398
Sand-Smelt and Square-Tail	398
Common Grey Mullet	399
Gar-Pike	401
Group of Sticklebacks	404
Two-Spotted Sucker-Fish	407
Striated Serpent-Head	409
Climbing-Perch on Land	410
Paradise-Fish and Telescope-Fish	412
The Gurami	413
Pike-Head	414
Unicorn-Fish	415
Banks's Ribbon-Fish	416
Risso's Thornback	417
Silver-Dotted Pomacentrus	418
Striped Wrasse	420
Silvery Viviparous Wrasse	421
Tristram's Chromid	422
Blue-Finned Tube-Mouth	424
Pipe-Fish and Sea-Horse	425
Fucus-Like Sea-Horse	426
Eel-Like Lycodes	431
Haddock, Whiting, and Cod	432
Burbot and Wels	436
Parasitic Fish in Pearl-Shell	438
Lesser Sand-Eel	439
Mediterranean Muræna	446
Eels in the Mud	447
Bengal Short-Tailed Eel	450
Electric Eel	451
Group of Carp	457
Group of White-Fish	460
Tench	461
Bitterling, Bleak, and Gudgeon	462
Group of Bream	464
Sichel, Rapfen, and Beaked Carp	465
Group of Loaches	467
Angola Loach	468
The Piraya	469
Head of Cyprinodont	470
Female and Male Double-Eye	471
Kentucky Blind-Fish	472
Common Pike	473
Beaked Fish and Slender Pikelet	475
Bornean Feather-Back	476
Brazilian Arapaima	477
Chisel-Jaw and Moon-Eye	479
Beaked Salmon	480
Phosphorescent Sardine	482
Silvery Light-Fish and Hedgehog-Mouth	483
The Dorab	484
Long-Finned Herring	485
Skeleton of a Saurodont	486
Shad, Sprats, and Herring	488
Black Smooth-Head	491
Zebra Salmon	492
Salmon and Sea-Trout	493
May-Trout and Hucho	499
Grayling and Charr	501
Common Smelt	503
Maranes	505
Bony-Pike	507
The Bow-Fin	508
Skeleton of Extinct Amioid	509
Jaw of Pycnodont	509
Giant Scale-Tooth	510
Spoon-Beaked Sturgeon	513
Sterlet	515
Extinct Acipenseroid Fish	516
The Bichir	517
Skeleton of Hollow-Spined Ganoid	518
Hammer-Headed Shark	521
Spiny Dog-Fish and Smooth-Hound	525
Indo-Pacific Basking-Shark	528
Lesser Spotted Dog-Fish and its Eggs	529
Port Jackson Shark	531
Lower Jaw of Port Jackson Shark	531
Teeth of Comb-Toothed Sharks	532

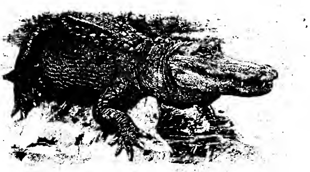
PAGE
Frill-Gilled Shark, 533
Angel-Fish, 536
Japanese Saw-Fish, 537
Halavi Ray, 539
Thornback Skates, 540
Jaws of Thornback, 541
Common Skate and Marbled Electric Ray, 542
Teeth of Lobe-Finned Shark, 546
Restoration of Fold-Finned Shark, 547
Restoration of Spine-Finned Shark, 547

THE LOWEST VERTEBRATES AND THEIR ALLIES

PAGE
Group of Lampreys, 551
Hag-Fish, 553
Skeleton of Primeval Lamprey, 554
Restoration of *Pteraspis*, 555
Restoration of *Cephalaspis*, 556
Restoration of *Pterichthys*, 556
Lancelet, 558
A Leathery Sea-Squirt (*Microcosmus*), 561
Section of Sea-Squirt, 562
A Cartilaginous Sea-Squirt (*Phallusia*), 565
Pear-Shaped Ascidian (*Hypobythius*), 566
A Creeping Ascidian (*Clavelina*), 567
An Incrusting Ascidian (*Botrylloides*), 568
A Compound Ascidian (*Amaroucium*), 568
An Individual of a Chain Salpa, 570
Botryllus, 572
Young *Balanoglossus*, 573
A *Pyrosoma* Colony, 576



THE ROYAL NATURAL HISTORY.



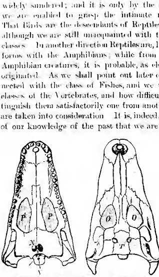
GAMBIER BOLTON, F.Z.S

REPTILES.

CHAPTER I.

General Characteristics,—Class **Reptilia**.

In ordinary language the term Reptile is applied indifferently to such creatures as crocodiles, tortoises, lizards, snakes, frogs, and salamanders, but by the naturalist it is used in a more restricted sense, and includes only the first four of these, together with a host of extinct types; while the frogs and salamanders, with certain other forms, both living and extinct, on account of important structural differences, constitute a class by themselves, known as the Amphibians, and bearing the same rank as the class of Reptiles. To an ordinary observer there would seem but little in common between a scaled lizard or snake, a cuirassed crocodile, and a carapaced tortoise, on the one hand, and a feathered bird on the other. Nevertheless, as we have had occasion to mention at the close of the preceding volume, the connection between Reptiles and Birds is exceedingly intimate,—so close, indeed, that Professor Huxley has termed the latter greatly modified Reptiles. At the present day the two groups are, indeed, somewhat widely sundered; and it is only by the study of forms long since extinct that we are enabled to grasp the intimate relationship that exists between them. That Birds are the descendants of Reptiles may accordingly be taken for granted, although we are still unacquainted with the immediate links connecting the two classes. In another direction Reptiles are, however, connected through other extinct forms with the Amphibians; while from these intermediate, half-Reptile, half-Amphibian creatures, it is probable, as elsewhere mentioned, that Mammals have originated. As we shall point out later on, Amphibians are also intimately connected with the class of Fishes, and we thus see how closely allied are all the classes of the Vertebrates, and how difficult is the task of the naturalist to distinguish them satisfactorily one from another when the whole of the extinct forms are taken into consideration. It is, indeed, solely from the still imperfect condition of our knowledge of the past that we are enabled to formulate any definitions at all, for had we the whole chain of organised nature before us, it will be obvious that no breaks would exist, but that every group would pass by imperceptible degrees into the earlier one from which it originated.



LOWER AND UPPER SURFACES OF THE SKULL OF A CROCODILE.

N, aperture of the internal or posterior nostrils; *O*, sockets of the eyes; *P*, vacuities of the palate; *T*, frontal vacuities, or fossæ; *V*, condyle of the occiput.

Proceeding to the consideration of what constitutes a Reptile, as distinct from any other animal, we may first point out some of the features in which Reptiles agree with Birds, and thereby differ from Mammals. In the first place, the skull articulates with the first vertebra by a single knob or condyle (*V* of the figure); while each half of the lower jaw is composed of several distinct bones; and the whole lower jaw articulates with the skull by the intervention of a separate quadrate-bone[1]. Then, again, both agree in that the appendages developed from the outer layer of the skin never take the form of hairs, while the young are not nourished by means of milk secreted by special glands on the body of the female parent, neither are gills developed at any period of life, throughout which respiration is effected by means of lungs. A further resemblance is shown in the position of the ankle-joint between the upper and lower rows of small bones entering into the composition of that part of the skeleton. In producing their young from eggs (sometimes retained within the body of the parent until hatched), Reptiles resemble not only Birds, but likewise the lowest Mammals; with which they also agree in the nature of the investments surrounding the embryo. As regards the distinction between the two groups, Reptiles are broadly separated from Birds by the absence of feathers, the appendages of the outer layer of the skin being in the form either of overlapping horny scales, or of large shields uniting by their opposed edges. Moreover, all known Reptiles differ from Birds in having more than three digits in the fore-limb, while in no cases are the collar-bones fused into a furcula as they are in all flying Birds. A further distinction is to be found in connection with the circulatory system, the blood of all existing Reptiles being cold, while the aorta, or great propelling blood-vessel of the heart is double, and crosses both branches (instead of only the left branch) of the windpipe. It will be obvious, however, that these two last characters cannot be verified in the case of extinct Reptiles, among which it is quite probable that there may have been some in which the blood was warm. A similar remark will apply to the absence among living Reptiles of those ramifications of the bronchial tubes throughout the body, which form such a characteristic feature in the structure of Birds. As additional features in the skeleton, it may be noticed that Reptiles never have the terminal faces of the vertebræ saddle-shaped; while in those forms in which the number of toes in the hind-limb is reduced to three, the metatarsal bones do not unite to form a cannon-bone in conjunction with the lower row of bones belonging to the ankle-joint. Then, again, with the exception of one remarkable extinct group, Reptiles, as a rul[illegible] are characterised by the three bones of the pelvis remaining distinct from one another through life; whereas in all existing birds they are welded together. There are likewise differences in regard to the form and structure of the breast-bone and sacrum, into the consideration of which it will be unnecessary to enter in this work.

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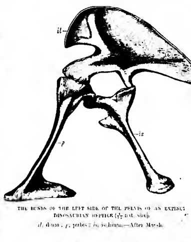
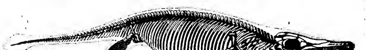
[1] In the figure the quadrate-bones are the prominences at the hinder external angles on either side of the letter *N*.



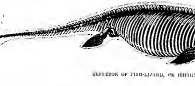
THE BONES OF THE LEFT SIDE OF THE PELVIS OF AN EXTINCT DINOSAURIAN REPTILE ($\frac{1}{12}$ nat. size).
il, ilium; *p*, pubis; *is*, ischium.—After Marsh.

Diversity of Form and Structure. In marked contrast to the uniformity in appearance and structure characterising Birds, the various groups of Reptiles differ widely from one another, both as regards external form and internal structure. Externally, a lizard, a snake, and a tortoise present the most marked differences in general appearance among living members of the order; while among extinct types there were some which walked on their hind-limbs alone, after the manner of Birds, and others having their fore-limbs modified into wings and the digits connected by a leathery membrane like that of bats. In a typical Reptile, such as a lizard or crocodile, both pairs of limbs are well developed, and of approximately equal length; but in the snakes all external traces of limbs have disappeared; while in the extinct flying dragons, or Pterodactyles, the fore-limbs much exceed the hind ones in size, and in many of the so-called Dinosaurs, which are likewise extinct, the excess in size falls to the share of the hinder pair of limbs. In other cases, again, the limbs may be modified into paddles, adapted for progression in the water, as in the existing turtles, and the extinct fish-lizards or Ichthyosaurs; the body in the latter assuming a somewhat fish-like form. In nearly all cases Reptiles have long and well-developed tails; although in some of the flying dragons these become rudimentary.



SKELETON OF FISH-LIZARD, OR ICHTHYOSAUR.

A large number of Reptiles are characterised by the development of bony plates within the deep layer of the skin; such plates, which are well displayed in existing crocodiles, being overlain by horny shields, and thus corresponding in every respect with those forming the carapaces of the armadilloes among Mammals. Among certain extinct Dinosaurs these bony plates attain a development unparalleled at the present day; and in some they are believed to have occupied the extraordinary position shown in the accompanying figure.

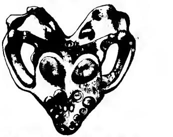


RESTORED SKELETON OF ARMOURED DINOSAUR (about 1/30 nat. size).

sc, shoulder-blade, or scapula; *co*, coracoid; *h*, upper arm-bone, or humerus; *r*, *u*, bones of fore-arm, or radius and ulna; *c*, wrist or carpus; *mc*, metacarpus; *il*, haunch-bone, or ilium; *p*, pubis; *is*, ischium; *f*, thigh-bone, or femur; *ti*, *f*, bones of lower leg, or tibia and fibula; *ta*, ankle, or tarsus; *mt*, metatarsus.—After Marsh.

Still more remarkable differences exist with regard to the form and structure of the teeth; which, instead of being, as in the two preceding classes, strictly confined to the borders of the jaws, may be spread over the entire palate. In spite, however, of this diversity of form, the teeth of Reptiles differ from many of those of the majority of Mammals in that they are never implanted in the jaws by two or more roots, while in no cases are their crowns complicated by the presence of infoldings of enamel. The simplest type of reptilian tooth is in the form of a cone; such conical teeth being confined to the margins of the jaws, where, as among crocodiles, they may be implanted in distinct sockets, or, as in the extinct fish-lizards, in an open groove. In other cases, as among lizards, teeth of the same general type may be united by a bony deposit either to the summit or to one side of the margin of the jaw. In place of the one regular replacement characterising the anterior teeth of the majority of Mammals, the teeth of most Reptiles are replaced irregularly and continuously throughout life, the successional teeth growing up beneath the bases of those in use, and gradually causing an absorption of their roots. When teeth are distributed over the whole or a greater portion of the palate they generally assume a more or less flattened and bean-like shape, so as to form a kind of pavement in the mouth, as shown in the accompanying figure of the under surface of the skull of an extinct reptile.

CONICAL TOOTH OF AN EXTINCT PLESIOSAURIAN REPTILE.



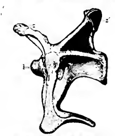
UNDER SURFACE OF SKULL OF AN EXTINCT REPTILE (*Cyamodus*), WITH PAVEMENT-LIKE TEETH ON THE PALATE.

LEFT SIDE OF THE SKULL OF A BEAKED FLYING DRAGON (⅛ nat. size).

a, vacuity in front of the eye; *b*, socket of the eye; *c*, occipital spine; *d*, angle of lower jaw; *e*, extremity of upper, and *e′* of lower jaw; *g*, articulation of the skull proper with the lower jaw; *i*, point where the two branches of the lower jaw diverge.—After Marsh.

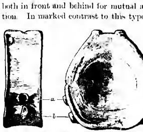
Between conical and pavement-like teeth there are various intermediate grades, some of which will be referred to in the sequel. It is, however, by no means all members of the class that are provided with teeth; the tortoises and turtles being living examples of the total loss of these organs, and the consequent conversion of the jaws into horn-clad beaks. Certain representatives of the extinct flying dragons were likewise devoid of teeth; and as in these forms the horn-covered jaws were long and narrow, the resemblance to the beak of a bird becomes most marked.

It has already been stated that the vertebræ of Reptiles never articulate by means of those saddle-shaped surfaces so characteristic of Birds. They present, however, great diversity of structure in this respect. In some cases, for instance, as in the fish-lizards, the bodies or central portions of the vertebræ are very short from front to back, and have concave surfaces both in front and behind for mutual articulation. In marked contrast to this type is the neck vertebra of a Dinosaur, where the anterior end of the body of each vertebra forms a convex knob (*b*), received into a cup at the posterior end of the vertebra in advance.[1] In other instances, as in the existing crocodiles and lizards, an arrangement precisely the reverse of the last is present; that is to say, the ball is at the hinder end and the cup at the front of the body of the vertebra. In a few lizards and in all snakes the vertebræ are further complicated by the development of additional articular facets, taking the form of wedge-like projections from one vertebra, which are received into cavern-like excavations in the adjacent one.



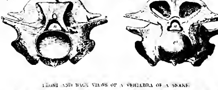
LEFT-SIDE VIEW OF A NECK VERTEBRA OF A DINOSAUR.

b, anterior ball.—After Marsh.



SIDE AND FRONT VIEWS OF THE BODY OF A VERTEBRA OF A FISH-LIZARD.

a, *b*, attachment of ribs.



FRONT AND BACK VIEWS OF A VERTEBRA OF A SNAKE.

n indicates the additional articular process, which is received into the cavity zs.

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[1] It should be mentioned that in this figure only the portion of which *b* is the extremity corresponds with the whole of the specimen represented in the other figure on the same line.

Omitting mention of certain features connected with their osteology, it may be observed that among those reptiles with four or five toes to each foot, while a few, such as certain tortoises, have the same number of joints in each toe as Mammals,—that is to say, two in the first toe, and three in each of the others,—in the greater majority there is a departure from this simple arrangement. In the lizards, for instance, the number of joints in the toes (reckoning from the first to the fifth digit) is 2, 3, 4, 5, 3 in the fore limb, and 2, 3, 4, 5, 4 in the hind-limb, while in crocodiles, where there are but four toes in the latter, the numbers are respectively 2, 3, 4, 4, 3, and 2, 3, 4, 4. In this increasing number of joints in the toes from the first to the fourth, such reptiles approximate to birds.

As regards their soft internal parts, Reptiles are characterised by the low development of their brains, which, in conjunction with their cold blood, accounts for the generally sluggish movements of their existing representatives. With the exception of the crocodiles, Reptiles differ from Birds in that the heart has only three, in place of four, complete chambers, thus causing the freshly oxygenated blood returning from the lungs to be mixed with the effete blood which has traversed the body. Even in crocodiles, where the heart has practically four chambers, the fresh and effete blood is partially mingled, owing to a communication between the vessels just outside the heart. Like Birds, Reptiles never have a midriff completely separating the cavity of the chest from that of the abdomen.

Classification and Distribution.

Reptiles having come into existence at an earlier period than either Mammals or Birds, and attaining an enormous development during epochs when both those groups were but feebly represented, it would be only natural to expect that they should have suffered to a much greater extent by the extinction of types with the lapse of time. As a matter of fact this is found to be the case; the number of existing orders of Reptiles being now but four (of which one is represented by only one or two species), whereas, if we include the extinct types, at least nine orders may be recognised. These nine orders, of which the extinct ones are indicated by asterisks (*) may be named and arranged as follows, viz.:—

1. CROCODILES—Crocodilia.
*2. DINOSAURS—Dinosauria.
*3. FLYING DRAGONS—Ornithosauria.
4. TORTOISES and TURTLES—Chelonia.
*5. PLESIOSAURIANS—Plesiosauria.
6. LIZARDS and SNAKES—Squamata.
*7. FISH-LIZARDS—Ichthyosauria.
8. TUATERAS, or BEAKED-LIZARDS—Rhynchocephalia.
*9. MAMMAL-LIKE REPTILES—Anomodontia.

Of these groups, by far the most numerously represented at the present day is the one containing the lizards and snakes, all of which are highly specialised forms, occupying a position in the class analogous to that held by the perching birds in the preceding class; the majority being comparatively small or medium-sized forms. Next in point of numbers come the tortoises and turtles, all of which are protected by the presence of a bony carapace, and some of which attain very large dimensions. The third numerical position in the fauna of the present day is held by the crocodiles, of which there are some twenty-four species, all of relatively large size, and all more or less aquatic in their habits. The fourth existing order is now represented only by the lizard-like New Zealand tuateras, of which there is probably but a single species; although in past times there were a host of allied forms. Of the five extinct orders the whole, or nearly the whole, of their representatives ceased to exist with the close of the Secondary period, that is to say, soon after the deposition of the chalk, and previous to that of the overlying London clay. During that long period, or "world of reptiles," the class attained a development which it never equalled before or since. The Dinosaurs, which were by far the largest of all land animals, then filled the place now occupied by Mammals; the flying dragons played the rôle of the bats and birds of the present day; while the marine Plesiosaurs and fish-lizards did duty for whales and porpoises. Of the mammal-like Reptiles, it will suffice to speak in the sequel. With regard to the past distribution of the four existing orders, it may be mentioned that the lizards and snakes, with the exception of two extinct suborders, are practically unknown before the commencement of the Tertiary period—that is to say, until after the deposition of the Chalk; hence they may be regarded as essentially the Reptiles of the present day, when they attain their maximum development. The tortoises and turtles, although a much more ancient group, having existed throughout the Secondary period, are, however, still at or about their zenith. The case is, however, very different with the crocodiles, which were represented during the Secondary period by a host of forms quite unlike those of the present day, and probably more numerous in species than their existing representatives. Many of the extinct crocodiles also exceeded any of the living forms in point of size. Still more markedly is this diminution noticeable in the case of the tuateras, in which a solitary survivor represents a once abundant group.

Owing to the exigencies of space, our remarks on the present distribution of the class must necessarily be brief. In the first place, it may be observed that while no existing Reptiles are denizens of the air, only the turtles and sea-snakes are habitual inhabitants of the ocean. Of the terrestrial and fresh water forms, it has been found that the distribution does not coincide very closely with that of Mammals and Birds, so that the zoological regions into which the globe has been mapped out from the geographical distribution of the latter scarcely hold good for Reptiles. This discrepancy may, no doubt, be partly explained by the very early period at which certain groups of the class, such as crocodiles and tortoises, spread themselves over the surface of the globe. As regards the dispersive powers of Reptiles in general, these, according to Dr. Günther, are but limited. All these creatures, he writes, "are much specialised in their mode of life and propagation and ill-adapted to accommodate themselves to a change of external conditions. As air-breathing, cold-blooded animals they are unable to withstand prolonged cold; they are therefore entirely absent in the Arctic and Antarctic zones; and such as escape the effects of the winter months in temperate zones by passing them in a torpid condition in well-sheltered places are not peculiarly organised forms, but offshoots from those inhabiting warmer climes. The tropical and subtropical zones are the real home of the reptilian type, which there has reached its greatest development as regards size and variety of forms. In the north, Chelonians advance only to 50° latitude in the Western and to 56° in the Eastern Hemisphere; lizards to about 56° in British Columbia, and close to the Arctic Circle in Europe, while snakes disappear some degrees before the lizards. Also in the south, lizards extend into higher latitudes than snakes, namely, to the Straits of Magellan, whilst the latter do not seem to have advanced beyond 40° south latitude, and Chelonians to 36°."

Of the various zoological regions into which the globe has been divided, the Oriental or Indian region, according to the same observer, is characterised by the number of fresh-water soft-tortoises[1] and S-necked tortoises,[1] land tortoises being scarce. Crocodiles, inclusive of the characteristic long-necked garials, are numerous, as are lizards and snakes—especially pythons. Africa is comparatively poorly off for Reptiles, although characterised by its numerous land tortoises, soft-tortoises, and side-necked tortoises;[1] the crocodiles being represented only by members of the typical genus; while lizards and snakes are comparatively numerous. Among the lizards, monitors, and among the snakes, pythons are common to the Oriental and African regions, while half of the exclusively Old World group of chamæleons are African. Madagascar is even more remarkable for the number of its chamæleons; its land and side-necked tortoises are numerous, although soft-tortoises, as in South America, are absent; there is one crocodile; and among the lizards the South American group of iguanas is abundant; while the snakes, among which none is poisonous, are also of a South American type. In the warmer parts of the Euro-Asiatic region (exclusive of India, etc.) the reptile fauna is mainly a mixture of Oriental and African types, although there are some peculiar forms. The only non-American alligator inhabits Central China. In the Australian or tropical Pacific region, exclusive of New Zealand, we meet with one group of land-tortoises, side-necked tortoises, and a crocodile; while amongst the lizards there are skinks, geckos, monitors, and the so-called agamoids; the latter occurring in all the regions above mentioned, except Madagascar. Venomous snakes here outnumber the harmless ones. The Tropical and South American region is characterised by the presence of land and side-necked tortoises to the exclusion of soft-tortoises. Crocodiles and caimans are numerous (the latter being characteristic); while of the abundant lizards the majority are iguanas, the true lizards (*Lacertidæ*) of the Old World being replaced by the teiias (*Teiidæ*); snakes are also numerous, among them being rattle-snakes and boas. In the North American region there are no caimans, their place being taken by an alligator; while fresh-water S-necked tortoises, as well as soft-tortoises replace the side-necked tortoises of the southern half of the continent. The snapping tortoises (*Chelydridæ*) are also mainly characteristic of this region, although one genus ranges as far south as Ecuador. As regards its lizards and snakes this region presents the same relation to the preceding as is held by Euro-Asia to the Oriental and African regions. Lastly, New Zealand stands apart from all other countries in possessing the remarkable tuatera, in addition to which its only reptiles are skinks and geckos.

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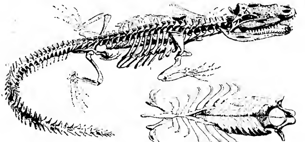
[1] For the explanation of these and other names, the reader must refer to later chapters.

CHAPTER II.

CROCODILES, DINOSAURS, and FLYING DRAGONS,—Orders CROCODILIA, DINOSAURIA, and ORNITHOSAURIA.

THE living crocodiles, among which may be included in a general sense not only the reptiles to which that name more properly belongs, but likewise those commonly designated alligators, caimans, and garials, are the only existing representatives of three orders, which comprise among their members not only the most highly organised of all Reptiles and those which approach nearest in their organisation to Birds, but likewise the largest of all terrestrial Reptiles, as, indeed, of any land animals. Although these three orders possess many characteristics in common, it will be more convenient to describe the leading features of each separately, in the course of which their common attributes will be pointed out.



SKELETON AND ABDOMINAL RIBS OF CROCODILE.

Characteristics of Crocodiles Sluggish in disposition, hideous in form, and huge in size, crocodiles alone among existing Reptiles serve in some measure to recall the giant Saurians with which the earth was peopled during earlier periods of its existence. In addition to their large bodily size, crocodiles are characterised by the lizard-like form of their bodies, which are supported on short limbs, and carried close to the ground. The long and powerful tail is much compressed from side to side so as to be an efficient propeller in swimming: its superficial extent being increased by a vertical longitudinal crest on its upper surface, this crest

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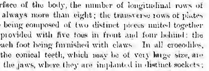
being formed of a double series of horny lobes in the basal half of the tail, beyond which it is single. The head terminates in a flattened snout of variable length, and is attached to the body by a short, although muscular neck; while the bulky body is much depressed. The toes are more or less webbed. Externally, the back, tail, and under-parts of these animals are protected by an armour of quadrangular horny shields of varying size, which are arranged in regular longitudinal and transverse rows, and are in contact with one another by their edges. In the region of the back, and sometimes also on the under surface of the body, these horny shields are underlain by a corresponding series of pitted bony plates. In the region of the neck, among existing members of the order, these bony plates are often irregular in form and vary in number, but on the back they are always quadrangular and broader than long, with a well-marked longitudinal ridge down the middle. Such plates form a considerable number of longitudinal rows; each plate articulating by its edges with those on either side, while those of each transverse row overlap those immediately behind them. When a bony shield is developed on the under surface of the body, the number of longitudinal rows of plates in existing forms is always more than eight; the transverse rows of plates overlapping and each plate being composed of two distinct pieces united together by suture. The limbs are provided with five toes in front and four behind; the three innermost digits in each foot being furnished with claws. In all crocodiles, whether living or extinct, the conical teeth, which may be of very large size, are confined to the margins of the jaws, where they are implanted in distinct sockets; while those in use are continually being replaced by fresh ones growing from beneath. These animals are further characterised by their nostrils opening at the extremity of the snout—which may be either short or long—and by their ears being covered with movable lids.

Such are some of the leading external features of these reptiles, and although they would suffice to distinguish them from the living members of the order, they are insufficient to determine their true affinities. Laying stress upon the above-mentioned characters of their teeth, the naturalist is accordingly compelled to resort to the skeleton and soft internal parts for more distinctive characters. In the skull all crocodiles are characterised by the quadrate-bone (of which the position is indicated in the figure on p. 2) being firmly united with the adjoining bones; while a further distinctive feature is to be found in the presence of two bony bars on the sides of the skull behind the socket for the eye, the uppermost of these arches being shown immediately below the letter *T* in the accompanying figure, while the lower and more slender one forms the backward continuation of the inferior margin of the eye-socket. The more anterior ribs (which, as in other Reptiles, are present in the neck as well as in the chest) generally articulate with the backbone by means of two distinct heads, and, while collar-bones are wanting, there is a breast-bone and likewise an inter-



SIDE VIEW OF SKULL OF EXTINCT CROCODILE (*Pelagosaurus*).
O, socket for the eye; *T*, temporal pit or fossa.

clavicle; the latter being the median bar seen in the lower figure of the illustration on p. 10. A further peculiarity is the presence of seven or eight pairs of abdominal ribs in the wall of the abdomen, which have no connection with the proper ribs, and have their angle of union directed forwards.[1] As regards the soft parts, the heart differs from that of all other living Reptiles in having four complete chambers, so that the fresh and impure blood can only mingle by means of a communication between the great vessels externally to the heart; while there is also an incomplete midriff dividing the chest from the abdomen.

In addition to the preceding characters, which are common to all members of the order, there are certain others found only in the existing forms and some of their nearest extinct allies. One of the most remarkable of these peculiarities is the extremely backward position of the aperture of the internal nostrils, which in the dried skull, as shown on p. 2, is situated close up to the occiput, this being due to the development of special plates by the bones of the palate, which grow beneath the nasal passage, so as to form a floor to it, and thus completely cut it off from the cavity of the mouth. As the summit of the windpipe is continued upwards into this posterior aperture of the nostrils, crocodiles are enabled to breathe while their mouths are wide open and filled with water. Another distinctive feature of the group, also shown in the figure just referred to, is that the socket for the eye communicates freely behind with the lower temporal fossa. Then, again, all existing members of the order are characterised by the bodies of the vertebræ having the ball behind and the cup in front; while the ribs of the chest are provided with hook-like or uncinate processes resembling those of birds. In the region of the neck the ribs present the peculiarity of having backwardly projecting and overlapping processes, which effectually prevent these animals from turning their heads to one side.

Habits

Crocodiles are denizens of the tropical and subtropical regions of the globe, and are found in such latitudes wherever there are rivers or fresh water lakes of sufficient size for their mode of life; while one of the Indian species habitually resorts to the sea-coast, where it has been seen floating at a considerable distance from the land. All of them are excellent swimmers, and are mainly propelled when in the water by the aid of their powerful tails, the limbs being chiefly used when walking at the bottom of the water, or on the shore. When in repose crocodiles lie like logs either in the water or on the banks of the lakes or rivers they inhabit; but when in pursuit of their prey in the water they move with great speed, while they are also active on land. The young are, however, decidedly nimbler in their movements than are the adults. Exclusively carnivorous in the diet, some members of the order feed solely upon fish; while others in addition to fish, prey upon the flesh of all animals that come in their way. Adult crocodiles, writes Dr. Gunther, "attack every large animal which accidentally approaches them, and in overpowering it the whole of their powerful organisation is called into requisition. Seizing the victim between their capacious jaws, and fastening their long, pointed, conical teeth into its flesh, they draw it in one moment, by their weight and with a stroke of the tail, below the water and drown it. Their gullet is, however, much too narrow to allow of the passage of the entire body of the victim; and their teeth being adapted for seizing and holding fast only, and not for biting, they are obliged to mangle the carcase, tearing off single pieces by sudden strong jerks." This rending process is mainly accomplished by lateral movements of the head and front portion of the body. Too often, human beings, who incautiously bathe in crocodile-haunted waters, fall victims to these bloodthirsty reptiles; while there are instances of people being seized when merely stooping down to dip water from the river's marge. When seized, the only way for an unarmed man to escape is, it is said, to thrust his fingers into the creature's eyes and endeavour to gouge them out. To a considerable extent crocodiles are nocturnal in their habits, and during protracted droughts many of them at least are accustomed to bury themselves in the mud, where they become torpid.

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[1] These abdominal ribs, connected together by the ligament, are shown in the figure above referred to.

As regards their reproduction, crocodiles lay from twenty to sixty eggs, of the approximate size of those of a goose and invested with a hard, white shell. These are deposited in some hollow in the sand of the bank, where after being covered to a greater or less depth, they are left to hatch. Whether the parent always assists in the incubation does not appear certain, although this has been proved to be the case in Madagascar by Dr. Voeltzkow. In that island the egg-laying season lasts from the end of August to the end of September; the usual number of eggs in a nest varying from twenty to thirty. The nest is excavated to a depth of about two feet in the dry white sand, its lateral walls being undermined so as to allow the eggs to roll into the cavities thus formed from the slightly elevated centre. Upon the summit of the completed nest, which is not noticeable externally, the parent sleeps; and when the young crocodiles are ready for hatching they utter distinct notes, which are heard by the mother even through a layer of two feet of sand. Digging down to the eggs, the parent crocodile lays them open to the air, upon which the young reptiles make their way out by perforating the shell at one extremity by the aid of a tooth specially developed for this purpose, the whole process occupying as much as a couple of hours. When hatched, the young crocodiles are led to the water by their parent, whose attention they attract by uttering cries, which are, however, of a lower pitch than those emitted while still in the egg.

EXISTING CROCODILES.

Family *CROCODILIDÆ.*

Caimans. The whole of the existing members of the order are included in a single family, which may be subdivided into half a dozen generic groups. Of these, in some respects the most specialised are the caimans and alligators, which, although closely allied, are now generally regarded as belonging to distinct genera. Both caimans and alligators are characterised by their relatively short and broad snouts, in which the edges of the jaws are festooned, and the nasal bones extend forwards to the aperture of the nostrils,[1] while the two halves of the lower jaw are united in front by a very short bony union. The stout teeth vary considerably in size in different parts of the jaws; the third and ninth in the upper jaw, the fourth, and frequently also the first and eleventh, in the lower, being generally much larger than the others. In these features caimans and alligators resemble many of the true crocodiles; from which they are distinguished by the circumstance that, as a rule, both the first and the fourth tooth on each side of the lower jaw are received into pits in the upper jaw, so as to be invisible externally when the mouth is closed; while the upper teeth bite on the outer side of the lower ones. Moreover, the number of teeth varies from seventeen to twenty on each side of the upper jaw, and from seventeen to twenty-two in the lower jaw. Then, again, both these groups are characterised by the very small size of the upper temporal fossæ on the top of the skull, or those marked *T* in the figure on p. 13: these fossæ being in some cases completely obliterated. Caimans are specially distinguished by the aperture of the nostrils not being divided in two by the nasal bones, by the presence of a strongly developed bony armour on the inferior surface of the body, and by the bony plates on the upper surface being articulated together.

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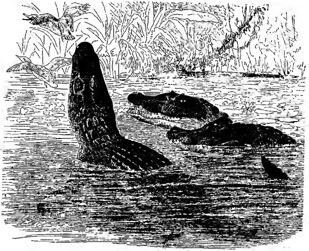
[1] This is shown in the figure on p. 2, where the nasals are the paired bones on the upper aspect of the skull, of which the narrow points just project into the cavity of the nostrils.



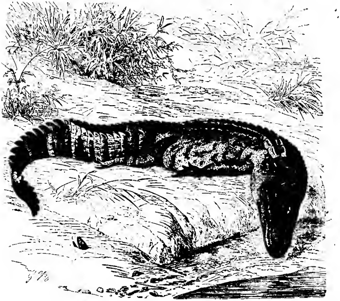
SPECTACLED CAIMAN ($\frac{1}{15}$ nat. size).

Caimans, or jacares, as they are called by the natives of Brazil, are restricted to Central and South America, where they are represented by five species. Of these, the largest, and at the same time the best known, is the black or great caiman (*Caiman niger*), from the rivers of tropical South America eastwards of the Andes, which takes its name from the black of the upper surface of the body, the under-parts being yellow. This species, which generally attains a length of about 14 feet, is characterised by its partially bony and flat upper eyelid, by the presence of upper temporal fossæ in the skull, by the number of teeth in each premaxillary or anterior upper jawbone being five, and the number of lower teeth being seventeen or eighteen. Nearly allied, although of much smaller size, are the broad-nosed caiman (*C. latirostris*), ranging from the Amazon to the Rio de la Plata, and the spectacled caiman (*C. sclerops*), from Central and South America, both of which have the upper eyelid rugose, with a small horn-like projection, while in the skull the socket of the eye does not extend so far forwards. Both are uniformly blackish when adult; but in the former the skull is very wide and the number of lower teeth from seventeen to eighteen, while in the latter the skull is narrower, and the lower teeth vary from eighteen to twenty. The two remaining species (*C. trigonatus* and *C. palpebrosus*) are still smaller, and characterised by the colour of the upper-parts being yellowish brown, spotted and barred with black; while the upper eyelid is completely bony, the skull has no upper temporal fossa, there are but four teeth in each premaxillary bone, and the number of lower teeth is from twenty to twenty-two on each side.

On the Amazon and Orinoco, as well as other South American rivers, caimans are to be met with in myriads, and appear to be very similar in their habits to the crocodiles of the Old World. Writing of the great caiman—jacare-nassu of the natives—Bates says that "it grows to a length of eighteen or twenty feet and attains an enormous bulk. Like the turtles the alligator [as he calls it] has its annual migrations, for it retreats to the interior pools and flooded forests in the dry season. During the months of high water, therefore, scarcely a single individual is to be seen in the main river. In the middle part of the Lower Amazon, about Obydos and Villa Nova, where many of the lakes with their channels of communication with the trunk stream dry up in the fine months, the alligator buries itself in the mud and becomes dormant, sleeping till the rainy season returns. On the Upper Amazon, where the dry season is never excessive, it has not this habit. It is scarcely exaggerating to say that the waters of the Solimoens are as well stocked with large alligators as a ditch in England is in summer with tadpoles." By the natives of these regions the caiman is at once despised and feared; the same traveller relating how on one occasion he saw a party boldly enter the water and pull to shore one of these large reptiles by its tail; while at another time two medium-sized specimens that had been captured in a net were coolly returned to the water hard by where a couple of children were playing. Sometimes, however, they have to pay dearly for such temerity. The Indians of Guiana, according to Waterton, capture the caiman by means of a baited hook and line, the former being composed of several pieces of wood, which become fixed in the creature's jaws. Waterton's account of his ride on the back of a caiman thus caught is probably familiar to many of our readers; and we have read of a similar feat being accomplished elsewhere. The eggs of the great caiman, which are about the size of those of a turkey, are said to be not unfrequently deposited in a heap of dry leaves, and are much sought after as food by the natives of Dutch Guiana.

Alligators The early Spanish settlers of South America on meeting with a gigantic lizard-like reptile naturally applied to it the name of *una lagarto*, which is the Spanish term for a lizard, and this as naturally became in course of time corrupted into alligator. It would appear, indeed, that this name was first given to the caiman, to which in strict propriety it should therefore belong; but now, by the common consent of naturalists, it is taken as the special designation of the members of the present genus. The alligators, as thus restricted, are represented by one species from North America, and by a second from the Yang-tse-Kiang in China; while there is also a third and imperfectly known species, of which the habitat is as yet undetermined. The alligators differ from the caimans merely by the forward prolongation of the nasal bones of the skull, so as to divide the aperture of the nostrils into two equal moieties, by the want of articulation between the bony plates of the back, and the absence or extreme thinness of those on the lower surface of the body. Curiously enough, the Chinese alligator (*Alligator sinensis*), which is a comparatively small species, is the one coming nearest in structure to the caimans; this approximation being shown by the great development of bone in the upper eyelid, and the presence of thin bony plates on the lower surface of the body. The latter are, however, placed wide apart, without any mutual articulation or overlapping. In this species the front toes are free, the number of plates on the neck is usually six, although these may be reduced to four, while generally there are but six plates in the widest of the transverse rows on the back. The number of teeth in the upper jaw is seventeen or eighteen against eighteen or nineteen in the lower. In colour the upper-parts are greenish black, speckled and streaked with yellow; while the under-parts are greyish. In the much larger Mississippi alligator (*A. mississippiensis*), of which the dimensions exceed those of the great caiman, the front toes are webbed, there are but four plates on the neck, and there are always eight plates in the widest of the transverse rows of the back. There are nineteen or twenty teeth on each side of both jaws; and in the adult the colour is dark green or blackish above, and yellowish below. The range of this species embraces the South-Eastern United States, from the Rio Grande to North Carolina. The third species (*A. helois*) is a small one, distinguished by the slight compression of the tail, which is scarcely crested.

Our knowledge of the Chinese alligator (which was first made known to science in 1879) in the living state is mainly or entirely derived from specimens exhibited in the menageries of Europe; while the accounts of the mode of life of the Mississippi species are by no means so full as is desirable. It appears, however, that the latter spends the greater part of its time in the water, where its main diet is formed by fish, although it will seize and drag such sheep, goats, dogs, deer, or horses, that, while drinking, come within reach of its terrible jaws. During flood-time, when many of the lowlands are under water, the alligators leave the rivers to feed on the fish which abound in the flooded districts; returning to their old quarters with the subsidence of the inundations. To such flooded lowlands, writes Audubon, "in the early part of the autumn, when the heat of a southern sun has evaporated much of the water, the squatter, the hunter, the planter, all go in search of sport. The lakes then are about two feet deep, having a fine sandy bottom. . . . The long, narrow Indian canoe, kept to hunt these lakes, and taken into them during the freshet, is soon launched; and the party seated in the bottom is paddled, or poled, to look for water-game. Then, on a sudden, hundreds of alligators are seen dispersed all over the lake, their head and all the upper part of their body floating like a log, and in many instances so resembling one, that it requires to be accustomed to see them to know the distinction. Millions of the large wood-ibis are seen wading through the water, muddling it up, and striking deadly blows with



MISSISSIPPI ALLIGATOR ($\frac{1}{30}$ nat. size).

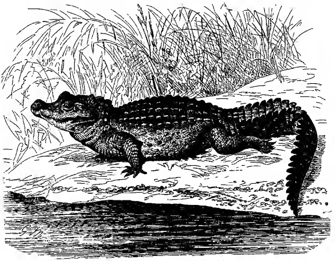
their bills on the fish therein. . . . It is then that you see and hear the alligator at his work: each lake has a spot deeper than the rest, rendered so by these animals who work at it; and always situated at the lower end of the lake." By this means a supply of water is ensured; and in these so-called alligators' holes the reptiles may be seen congregating in hundreds. "The fish, that are already dying by thousands through the insufferable heat and stench of the water, and the wounds of the different winged enemies constantly in pursuit of them, resort to the alligators' hole to receive refreshment, with a hope of finding security also, and follow down the little current flowing through the connecting sluices; but no! for, as the water recedes in the lake, they are here confined. The alligators thrash them, and devour them whenever they feel hungry, while the ibis destroys all that make towards the shore. By looking attentively on this spot, you plainly see the tails of the alligators moving to and fro, splashing and now and then, when missing a fish, throwing it up in the air. The hunter marks one of the eyes of the largest alligators, and as the hair-trigger is touched the alligator dies. Should the ball strike one inch astray from the eye, the animal flounces, rolls over and over, beating furiously about him with his tail, frightening all his companions, who sink immediately; whilst the fishes, like blades of burnished metal, leap in all directions out of the water, so terrified are they at this uproar."

During the pairing-season, which takes place in the spring, the males resort to the land, and are but seldom seen; while soon after the female deposits her hard white eggs, which are said at times to be upwards of one hundred in number. The nest in which the eggs are laid is generally placed among bushes or reeds, at a distance of fifty or sixty yards from the water's edge; the eggs themselves being carefully covered with leaves and other vegetable matter. The heat engendered by the decomposition of the latter, aids in the hatching of the eggs; and when the young appear, they are conducted to the water by the mother, who has all the time remained on guard near the nest.

Double-Tusked Alligators. In the middle and lower Tertiary deposits of both Europe and the United States, the present group was represented by certain extinct alligators (*Diplocynodon*) characterised by the presence of a bony armour on the lower surface of the body, coupled with the circumstance that the fourth tooth of the lower jaw was generally received into a notch in the side of the skull, while the third lower tooth was as much enlarged as the fourth. Some of these double-tusked alligators had short snouts, like their existing allies; but in one from the London Clay this part of the skull was much produced, as in many crocodiles.

Stumpy Crocodile. A small and short-nosed crocodile (*Osteolaemus tetraspis*) from West Africa, in the neighbourhood of Sierra Leone, where it was discovered by Du Chaillu, presents much the same relationship to the true crocodiles as is held by the alligators to the caimans. Thus, while the arrangement of the teeth is similar to that obtaining in the true crocodiles, the nasal bones extend forwards to divide the cavity of the nostrils into two halves. Moreover, the upper eyelid is largely bony, while there are detached bony plates on the lower surface of the body, as well as on the throat. The shield of the neck is distinct from that of the back, and is composed of two or three pairs of plates, of which the anterior ones are very large; while that of the back comprises seventeen transverse rows of plates, the broadest row including six of such plates. The ridges on the plates of the neck are strongly marked, but they become very obscure in the two middle rows of the back. The fore-toes have only rudimentary webs, although those of the hind-limbs are webbed for about half their length. With the exception of parts of the head, tail, and back, which are light brown with black markings, the coloration of the adult is uniform blackish brown. Young specimens are however yellowish brown, spotted with black above, and with bars of the same on the body and tail; while the lower armour is black and yellow. Practically nothing is known as to the habits of this peculiar species, which are, however, probably very similar to those of its allies.

True Crocodiles. The true crocodiles comprise rather less than a dozen species, ranging over Africa, Southern Asia, Northern Australia, and Tropical America. Having no bony armour on the lower surface of the body, they are distinguished from the caimans and alligators by the interlocking of the upper and lower teeth, and by the fourth lower tooth being usually received into a notch on the side of the upper jaw, so as to be partially visible when the mouth is closed, while the number of teeth varies from seventeen to nineteen on each side of the upper jaw, and fifteen in the lower. From the stumpy crocodile they are distinguished by the aperture of the nostrils in the skull not being divided by the forward prolongation of the nasal bones. While some of the species resemble the alligators in their broad and short snouts, others have elongated, narrow snouts, approaching those of the garials; but as there is an almost complete gradation from the one type to the other, this affords no ground for generic distinction, so that the most that can be done is to arrange them in groups.



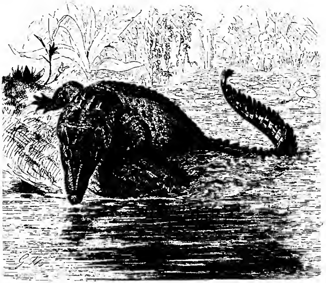
STUMPY CROCODILE ($\frac{1}{12}$ nat. size).

Indian Crocodile. Commonly known to the natives of India as the magar, and misnamed alligator by Anglo-Indians, the Indian crocodile (*Crocodilus palustris*) is the best known representative of a group of four species which, in their broad and short snouts, make the nearest approach to the caimans and alligators. In all these the length of the snout does not exceed one and a half times its basal width, the bony union between the two branches of the lower jaw does not extend behind the level of the fourth or fifth tooth; while on the palate the line of union between the anterior and main jawbones (premaxillæ and maxillæ) extends nearly straight across the skull, as shown in the figure on p. 2. The Indian crocodile has no bony ridges on the snout, while there are usually four longitudinal rows of bony plates on the back, and there are five teeth in each anterior upper jawbone or premaxilla. An allied species (*C. robustus*) from the interior of Madagascar, differs by having six longitudinal rows of plates on the back; while the Cuban crocodile (*C. rhombifer*) of Central America, and a nearly related species (*C. moreleti*), from Guatemala, are distinguished by having a more or less distinct oblique ridge in front of the eye.

The habitat of the Indian crocodile includes India, Ceylon, Burma, and the Malay Peninsula and Islands; its most westerly range being Sind and Baluchistan. Inhabiting rivers, lakes, and marshes, it appears to be an exclusively fresh-water species, never venturing into estuaries. As to the dimensions attained by this species there is some uncertainty, although it is probable that at the present day specimens seldom grow to the size that was reached before firearms were common. Nowadays from 12 to 14 feet appears to be a large size for this species, but a length of 18 feet has been recorded, while skulls in the Calcutta Museum would seem to indicate still larger individuals. A nearly allied extinct species has left its remains in the Siwalik Hills of Northern India. Swarming in most of the rivers and marshes of India, except where the current is too swift, the Indian crocodile is stated to be less ferocious than the species next mentioned, generally preying on the smaller animals, and not unfrequently dragging down a wounded or dead bird before the eyes of the gunner. When the waters they frequent become dried up these crocodiles will either travel across country by night to another lake or river, or bury themselves in the mud.

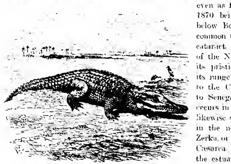
Estuarine Crocodile. Resembling its compatriot in its pale olive colour, conspicuously spotted with black, the estuarine crocodile (*C. porosus*), of India and other regions, may be at once distinguished by its longer and more slender snout, as well as by the presence of only four teeth in each anterior jawbone or premaxilla of the adult. It belongs, indeed, to a group of four species, differing from the preceding assemblage in the length of the snout varying from rather more than one and a half to just over twice its basal width; and also by the line of union between the anterior and main jawbones running in a V shape up the palate. The presence of a large ridge running down the skull in front of the eye serves to distinguish this species not only from all the other members of the group, but likewise from the Indian crocodile. The present species generally, if not invariably, inhabits the tidal portions of rivers, from whence it descends into the sea, where it has been observed floating at considerable distances from land. These estuarine and partially marine habits will readily account for the wide geographical distribution of this crocodile, which ranges from India to Australia. Unknown on the western coast of India, the estuarine crocodile is abundant in the lower courses of the rivers of Bengal and other parts of the eastern side of India, as well as in Ceylon and Burma, whence it extends eastwards to Southern China, Northern Australia, and the islands of the Solomon and Fiji groups. In point of size it probably surpasses all other species, one specimen being recorded which reached the enormous length of 33 feet.

In correspondence with its gigantic size, this crocodile appears to be one of the most formidable members of its kind, being exceedingly prone to attack human beings, more especially in the breeding-season, which takes place during June and July, when it is stated to attack such small boats as may cross its haunts. Owing to its depredations, these crocodiles are cordially detested as well as feared by the natives of India, and at Dacca, on the north of the Bay of Bengal, crocodile-hunting is pursued as a profession. The following account of the pursuit of one of these monsters which had recently carried off a boy is abridged from a native newspaper. The hunter, having been summoned, moored his canoe hard by the place where the tragedy had taken place, it being well known that a crocodile which has been successful in securing a victim will generally remain for some days about the spot. Soon the crocodile was descried floating on the water, whereupon the hunter and assistant hid themselves in the canoe, while the son of the former entered the water, which he commenced to beat with his hands. Catching sight



ESTUARINE CROCODILE ([illegible] nat. size) of the boy, the crocodile prepared to dive towards him, upon which the boy took refuge in the canoe. In a moment or so the reptile rose to the surface at the expected spot, where he was saluted with a couple of harpoons, one of which secured a firm hold. After a long chase, in which a number of the inhabitants of the village took part in boats, a second harpoon was safely planted in the head of the monster, who was finally dragged to shore. When opened, several gold and silver ornaments—the relics of earlier victims—were found in his stomach. In Ceylon, according to Sir J. E. Tennent, crocodiles are frequently captured by means of a hook and line, which are laid over-night in the water, and made fast, in the native fashion, by a bunch of fine cords. These cords becoming fixed between the interstices of the creature's teeth, are safe from being bitten through; and in the morning the captive is dragged ashore and despatched. It may be added that, when thus captured, crocodiles emit a disagreeable musky smell, due to the secretion of a pair of glands in the lower jaw.

Nile Crocodile. Formerly inhabiting the Nile from its mouth to its source, the Nile crocodile (*C. niloticus*), from the invasion of its haunts by steam vessels and the introduction of rifles, has now well-nigh disappeared from Egypt, even as far back as the year 1870 being but rarely seen below Beni Hassan, and not common till above the second cataract. In the upper reaches of the Nile it still exists in its pristine numbers, whence its range extends southwards to the Cape and northwards to Senegal. The species also occurs in Madagascar, while it likewise still lingers in Syria in the neighbourhood of the Zerka, or Crocodile River near Cæsarea. Distinguished from the estuarine crocodile by the absence of the ridge in front of each eye, this species differs from the other two members of the same group by the want of any ridge on the middle of the snout or forehead, so that its whole skull is comparatively smooth. In size it falls but little, if at all short of the estuarine crocodile; although differing from the latter by the uniformly dark olive colour of the adult.


NILE CROCODILE.

As the habits of this crocodile do not differ in any important respects from those of the other members of the genus, they do not require any detailed notice, although a few words must be devoted to its cult by the ancient Egyptians, among whom it was known by the name of *champsa*. By these remarkable people the crocodile was regarded as the symbol of sunrise—possibly, it has been suggested, on account of the brightness of its eye, or, perhaps, because that is the first part to appear when the creature emerges from the water. Among the places where the crocodile was specially reverenced were Thebes and the shores of Lake Moeris, as well as Ombi, near Syene. At Thebes a crocodile was reared from youth in the temple, where it was fed with sacred food, adorned with rings and bangles, and worshipped with divine honours; while after death its mummified body was carefully preserved in the catacombs, where hundreds of embalmed crocodiles are still to be found. Something analogous to this Egyptian veneration for the crocodile is to be met with in other countries. Leith-Adams tells us that the Indian crocodile is reclaimed by certain religious sects in India, being rendered so tame that it will leave its pond to feed out of its keeper's hand; while Mrs. R. B. Lee relates that at Dix Cove, on the north-western coast of Africa, a pair of tame crocodiles were kept in a pond by priests, dressed in white garments, who fed their charges with snow-white fowls.

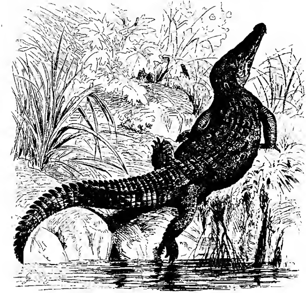
In the Upper Nile the favourite haunts of the crocodiles are sandbanks, situated in parts of the river where the current is not too strong. There they may be seen at all hours of the day sleeping with widely opened mouths, in and out of which the black-backed plover (as mentioned on p. 475 of the preceding volume) walks with the utmost unconcern. According to Arab accounts, one and the same crocodile has been known to haunt a single sandbank throughout the term of a man's life; thus leading to the conclusion that these creatures must enjoy a long term of existence, during the whole of which they continue, like other reptiles, to increase in size. In common with this feature of uninterrupted growth, all crocodiles are also distinguished by their remarkable tenacity of life; the shots that prove instantaneously fatal being those that take effect either in the brain itself or in the spinal cord of the neck. It is true indeed, that a shot through the shoulder will ultimately cause death; but it allows time for the animal to escape into the water, where its body immediately sinks. To reach the brain, the crocodile should be struck immediately behind the aperture of the ear. Although it is commonly supposed that the bony armour of these reptiles is bullet-proof, this is quite erroneous; if the plates are struck obliquely, the bullet will, however, frequently ricochet.

A remarkable instance of boldness and ferocity displayed by a crocodile of this species is narrated by a correspondent of the *Times* during a journey to Mashonaland. On arriving one evening at the banks of the narrow but rocky Tokwi River, a man named Williams rode in with the intention of crossing. During the passage his horse was carried by the stream a few yards below the landing-place, and just as he reached the opposite bank he was seized by the leg by a crocodile, which dragged him from his horse into the stream. There the reptile let go its hold, upon which the man managed to crawl on to a small island. Immediately his companion rode in to his assistance, upon which another very large crocodile mounted up between him and his horse's neck, and then slipped back, making a dreadful wound on his side and in the horse's neck with its claws as it did so. The river seemed, indeed, to be absolutely swarming with crocodiles; and it was with the greatest difficulty that the unfortunate man Williams, who ultimately died of his wounds, was brought to bank.

Siam Crocodile. The Siamese crocodile (*C. siamensis*), inhabiting Siam, Cambodia, and Java, may be distinguished from the preceding species by the presence of a longitudinal ridge on the skull between the eyes, although the snout is smooth. It agrees with the latter in having the anterior bony plates of the neck well developed, these being usually absent in the estuarine crocodile.

Sharp-Nosed Crocodile

The last member of this group is the sharp-nosed crocodile (*C. americanus*) of Central America, which has a longer and sharper muzzle than any of the preceding and is further characterised by the presence of a distinct median ridge running down the snout. There are usually four large bony plates on the neck, forming a square, with a smaller pair on the sides of the front ones; while the plates of the back are arranged in fifteen or sixteen transverse rows, and in either four or six longitudinal bands. In the fore-limb the second and third toes are but slightly webbed, while the outer toes of the hind-foot are united by larger webs. In coloration the adult is blackish olive above, and yellowish beneath; while the young are pale olive with black spots. In addition to being widely distributed in Central America and the adjacent regions,

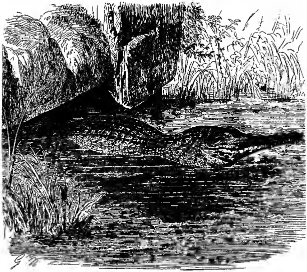


SHARP-NOSED CROCODILE ($\frac{1}{24}$ nat. size).

such as Ecuador, Colombia, Venezuela, and Florida, this crocodile is also met with in the West Indian Islands.

Orinoco Crocodile. Nearly allied to the last, although with a still longer and more slender snout, is the Orinoco crocodile (*C. intermedius*), which is referred by Mr. Boulenger to a third group, characterised by their very slender and garial-like snouts, of which the length is equal to at least twice the basal breadth; and also by the bony union between the two branches of the lower jaw extending as far back as the sixth, seventh, or eighth tooth, instead of stopping short at the fifth. In this particular species the snout, which has no ridges, varies in length from twice to twice and a half the width at the base; while the six bony plates on the neck are widely separated from those of the back, and are arranged in a square of four, with a pair on the sides. The colour is olive above and yellowish beneath, while in both this and the preceding species the length is about 13 feet. The Orinoco crocodile appears to be confined to the river from which it takes its name and its affluents. The best accounts of the Orinoco and sharp-nosed crocodile are by Humboldt, who states that these reptiles swarm on the Apure, where they may often be seen in parties of eight or ten lying on the open space between the shore of the river and the forest. At the time of his journey the river was, however, still low, and consequently hundreds of crocodiles were lying concealed beneath the mud of the adjacent lowlands. In the stomach of one that was opened were found a half-digested fish and a granite pebble; the latter having probably been swallowed inadvertently while the animal was groping about in the mud in search of food. In spite of their comparatively slender jaws, these crocodiles frequently seize the natives while stooping to draw water from the river. A large portion of their prey is, however, afforded by the defenceless carpinchos, which are met with in droves of from fifty to sixty head, and fall victims to the jaguars on land and to the crocodiles in the water. In their young state—when only from 7 to 8 inches in length—the crocodiles themselves are, however, devoured by vultures, who seize them on the shore or in the shallow water. It was curious, observes Humboldt, to see the address with which the little reptiles defended themselves for a time against their aggressors. As soon as they perceived the enemy, they raised themselves on their fore-paws, bent their backs, and lifted up their heads, opening their wide jaws. They turned continually, though slowly, towards their assailant to show him their teeth, which, even when the animal had but recently issued from the egg, were very long and sharp. Often, while the attention of one of the young crocodiles was wholly engaged by one of the vultures, another seized the favourable opportunity for an unforeseen attack, pouncing on the unfortunate reptile by the neck and bearing it off in the air. The anecdote told by Humboldt of a native of Calabozo being awakened in the middle of the night by one of these crocodiles suddenly breaking through the mud of the floor of his hut, beneath which it had retired for the dry season, is probably familiar to most of our readers.

Long-Nosed Crocodile. Omitting notice of the small Johnston's crocodile (*C. johnstoni*), of North Australia, the last member of the genus is the curious long-nosed crocodile (*C. cataphractus*), of West Africa, which forms a kind of connecting link between the other true crocodiles and the garials. In this species the snout is more elongated and slender than in any of its congeners, its length not unfrequently exceeding three times its basal width; the bony union between the two branches of the lower jaw being likewise of unusual length. In form the snout is convex, and devoid of ridges; while the region of the forehead is remarkable for its convexity. The great peculiarity about the species is, however, to be found in the arrangement of the bony plates on the neck, which form two longitudinal rows, and are partially if not completely continuous with those of the back, a somewhat similar arrangement existing in Johnston's crocodile. On the back the number of longitudinal rows of shields is six; and the lower parts of the legs, as in many other crocodiles, are furnished with a jagged horny fringe. In colour the head is olive spotted with brown: the back and tail have a brownish yellow ground-colour, with large black spots, while the yellowish white under-parts are marked with smaller white spots. In length this species reaches some 18 feet.



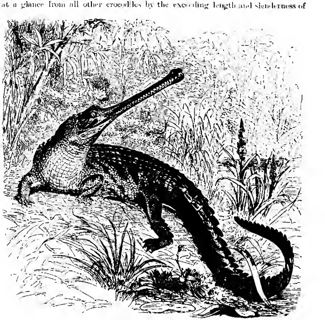
LONG-NOSED CROCODILE ($\frac{1}{20}$ nat. size).

The long-snouted crocodile is found in the rivers and marshes of West Africa, from Senegambia to the Gabun, and also occurs further to the south in the Congo; its native name being khinh. Not unfrequently found in company with the Nile crocodile, it inhabits the smaller streams and still waters of the interior, generally taking up its position in a deep pool protected by an overhanging bank or rock, and thence sallying forth on its prey, which consists chiefly of fish, frogs, and aquatic reptiles. The eggs are laid on the bank, where, unlike those of most other members of the family, they are carefully covered with leaves and herbage. Shy and timid in its disposition, this crocodile is often captured by the natives for the sake of its flesh; which, like that of many of its allies in other regions, is much esteemed as food. While very abundant in the fresh waters of the interior this species likewise haunts the salt-water lagoons of the Guinea Coast, and in the delta of the Cameruns may be observed lying on the sandbanks bordering the mangrove swamps, from which, on the approach of a boat, it darts into the water with surprising celerity. There it often pulls down herons and such other aquatic birds as may be standing or swimming in the water, sailing up to them with the silence of a large fish, to which, when in the water, it presents a considerable resemblance. As in the estuarine and Nile crocodiles, in the adult of this species the second tooth in the fore jawbone, or premaxilla, disappears, leaving only four in place of the normal five on each side.

Schlegel's Garial. With the very long and slender-snouted crocodile from Borneo, commonly known as Schlegel's garial (*Rhynchosuchus schlegeli*), we come to the first of two genera, each represented by a single existing Oriental species, which differ very remarkably from any of those yet noticed. In both these forms the snout is long and slender, with its teeth-bearing margins nearly straight, instead of being thrown into more or less well-marked festoons; while the nasal bones never extend forwards to reach the aperture of the nostrils, from which they are separated by a considerable interval. Moreover, the bony union between the two branches of the lower jaw is of great length, extending at least as far back as the fifteenth tooth; and including a bone which in the other crocodiles remains entirely separate from the symphysis. In neither do the teeth attain the large dimensions characteristic of many other members of the family.

Schlegel's garial has the shorter snout of the two, its length not exceeding three and a half times its basal width; but it is especially distinguished by the circumstance that the nasal bones extend forwards to articulate with the anterior jawbones, or premaxillæ. The teeth are twenty or twenty-one in number on each side of the upper jaw, and eighteen or nineteen in the lower; those on the sides of the latter being received in pits between the upper ones, and the first, fourth, and ninth lower teeth being enlarged. The bony plates on the neck and back form a continuous shield consisting of four longitudinal, and twenty-two transverse rows; and while the fore-toes are webbed at the base, the outer ones of the hind-feet have larger webs. In colour, Schlegel's garial is olive above, with dark spots or bars; while its length may be 12 or 14 feet. In habits this species is probably very similar to the Indian garial. It is important to notice that several fossil representatives of this genus occur in the Tertiary deposits of Europe while it is not improbable that the genus is also represented in the underlying Cretaceous rocks. All this is exactly in harmony with what we should naturally have expected to be the case, seeing that Schlegel's garial, like the true garial, is evidently a very generalised member of the family.

Garial. Probably owing to a clerical error on the part of its first describer the slender-snouted crocodile known in India by the vernacular name of garial, is almost always spoken of in Europe as the gavial, while its misspelt name has even been Latinised into *Gavialis*—an error which some writers persist in perpetuating. The garial (*Gavialis gangeticus*) is readily distinguished at a glance from all other crocodiles by the exceeding length and slenderness of



GANGETIC GARIAL ([illegible] nat. size)

its snout; the length varying from more than five times the basal width in the young to rather more than three in the adult. This narrow snout gives to the reptile a decidedly curious appearance; and it is perhaps noteworthy that both the garial and the gangetic dolphin which inhabit the same rivers and probably feed on the same kind of food, have similarly elongated beak-like snouts armed with very similar curved and slender conical teeth, this resemblance being doubtless due to adaptation to a similar mode of life. From Schlegel's garial, the present species is readily distinguished by the nasal bones being very short, and consequently separated by a long interval from the anterior jawbones, or premaxillæ; while the teeth—twenty-seven to twenty-nine on each side of the upper, and twenty-five or twenty-six in the lower jaw—are all of nearly uniform size, and those of the lower jaw are not received into distinct pits. Moreover, the bony union between the two branches of the lower jaw extends backwards to the twenty-third or twenty-fourth tooth, whereas in the Bornean species it stops short at the fourteenth or fifteenth. At its extremity the long and narrow snout becomes much expanded; and in the male this expanded extremity is surmounted by a hollow hump, in the centre of which are placed the nostrils. The bony plates of the neck form a shield continuous with that of the back, in which the number of longitudinal rows is four, while there are twenty-one or twenty-two transverse bands. Externally to the bony shields of the back there occurs on each side a row of soft plates, which are either smooth, or but slightly keeled. The toes are well webbed; and the general colour of the adult is dark olive above, the young being pale olive, with dark brown spots or bars.

The garial has a somewhat curious geographical distribution, being restricted to the Indus, Ganges, and Bramaputra, with their larger affluents, together with the Mahanadi in Orissa, and the Koladyni River in Arakan. Together with certain tortoises mentioned later on, this reptile is one of the most ancient of living animals, its fossil remains occurring in the rocks of the Siwalik Hills in Northern India in association with those of mammals belonging to extinct species and genera. Attaining a length of fully 20 feet at the present day, and still larger dimensions during the Pliocene period, the garial subsists solely upon fish, for the capture of which its elongated narrow jaws, armed with numerous long, curved teeth, are admirably adapted. There appears, indeed, to be no well authenticated instance of these reptiles having attacked human beings or the larger mammals; and it is perhaps owing to this harmless disposition that they are held sacred in many parts of India by the Hindus. In accordance with the nature of its prey, the garial seems to be more thoroughly aquatic in its habits than most of its allies; the relatively long hind-limbs and the fully-webbed toes being features specially suited to aid in swimming. In the breeding-season the female garial lays about forty eggs in the sand of the river bank, these being deposited in two layers, and covered to a considerable depth with sand; the two layers being probably laid on different days. The newly hatched young, which, from the great proportionate length of their snouts, present a most extraordinary appearance, are very active, and of a greyish brown colour, with five irregular dark oblique bands on the body, and nine on the tail.

Extinct Garials.

In addition to those of the existing species the Siwalik Hills have yielded remains of several extinct garials some of which attained gigantic dimensions; while other species belonging to the living genus have been obtained from the middle Tertiary rocks of England. Possibly, also, certain fossil garials from the Cretaceous deposits of the United States should find a place in the same generic group. Other Cretaceous species are, however, remarkable for the presence of a vacuity in the skull in front of the eye-socket, in consequence of which they have been separated as a distinct genus, under the name of *Thoracosaurus*. Mention must also be made of an enormous garial from the Siwalik Hills known as *Rhamphosuchus*, which attained a length of some 50 or 60 feet, and had teeth as large as those of the biggest crocodile; its upper teeth biting on the outer side of the lower ones, instead of interlocking with them, as in the living form.

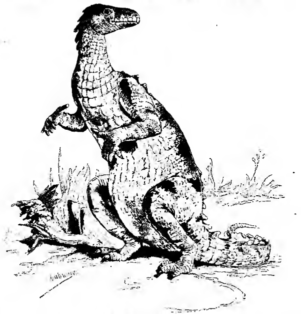
The Earlier Crocodiles

As already mentioned, all the existing crocodiles, together with the species from the Tertiary formations, constitute a single family, characterised by the vertebræ having a ball in front and a cup behind, and by the internal nostrils being situated at the hinder end of the skull; as well as by the bony plates of the back being arranged in at least four longitudinal rows. Although a few species found in the topmost beds of the underlying Secondary formations approximate in some respects to the foregoing, the majority of the crocodiles from rocks as old or older than the Chalk differ very considerably from the existing types. In the first place, the bodies of their vertebræ articulate with one another by slightly hollowed surfaces at both ends; while, owing to the want of union between the hindmost bones of the palate beneath the nasal passages, the internal apertures of the nostrils are situated nearly in the middle of the skull. Then again, when a bony armour is present, the plates on the back are arranged in only two longitudinal rows; while those on the lower surface of the body form two distinct shields. It is remarkable that among these extinct crocodiles some are met with having broad and short snouts like the modern alligators, while others have long and narrow snouts like the garials. In the Wealden and Purbeck rocks, underlying the Chalk, some of these crocodiles, such as the short-snouted Swanage crocodile (*Goniopholis*), resembled living types in having the socket of the eye communicating freely with the lower temporal fossa, although they were distinguished by the plates of the back articulating together by means of a peg-and-socket arrangement. In still older formations, such as the Lower Oolites and Lias, there were, however, many long-snouted crocodiles, such as the steneosaurs (*Steneosaurus*) and pelagosaurs (*Pelagosaurus*), in which the socket of the eye is divided from the lower temporal fossa by a bony bar, as shown in the figure on p. 13. Moreover, in these forms the upper temporal fossa (*T* in the figure cited) was larger than the socket of the eye; whereas in all living forms the former is much the smaller of the two, and may even be obliterated. Another group of crocodiles,—the metriorhynchs (*Metriorhynchus*),—of the Oxford and Kimeridge Clays, were remarkable in having no bony armour at all, in which respect they were more specialised than any of their living cousins. In general, however, the earlier extinct crocodiles, as will be gathered from the foregoing remarks, were decidedly of a less specialised type than those of the present day; and as a gradual transition can be traced in these respects from the oldest to the most recent, the group affords a very interesting instance of progressive evolution. In the very oldest of the secondary rocks, namely, the Trias, there occur, both in Europe and India, certain very remarkable long-snouted reptiles, known as Parasuchians, which appear in some respects intermediate between crocodiles and tuateras. Thus, while they resembled the former in the nature of their teeth, bony armour, ribs, and vertebræ, they approximated to the latter in the structure of the skull, abdominal ribs, and probably of the collar-bones and interclavicle.

THE EXTINCT DINOSAURS.

Order DINOSAURIA.

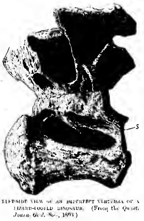
Nearly allied to crocodiles are those remarkable extinct reptiles from the rocks of the Secondary period, which include amongst their number the most gigantic of all land animals, and likewise those members of the reptilian class which make the nearest approximation in their organisation to birds. During that epoch of the earth's history in which the Chalk and underlying Oolitic rocks were deposited, when mammals were represented by a few small forms of lowly type, these strange reptiles were the dominant animals on land; some progressing in the ordinary lizard-like manner, while others stalked on their hind-limbs like birds. To give some idea of the enormous dimensions attained by some of these creatures, it may be mentioned that the thigh-bone of one species measures 64 inches, while the total



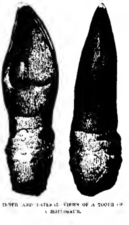
RESTORATION OF THE IGUANODON.

length of its skeleton is estimated to have been between 60 and 80 feet. On the other hand, some species were comparatively small, and not more than a couple of feet in length. Although the whole of these reptiles are markedly distinct from the crocodiles, yet they agree with them in the general characters of their skulls, vertebræ, and ribs; but they differ so decidedly from one another that it is not easy to give a definition of the entire order. They are, indeed, divided into three well-marked groups, with so many differences between them that in the opinion of many they are entitled to rank as separate orders; and it will, accordingly, be most convenient to treat these three groups *seriatim*.

Lizard Footed Group. The most stupendous members of the order are included in a group which may be conveniently designated lizard-footed dinosaurs, on account of their walking in the ordinary lizard-like manner, and in having five toes to the feet. The most striking peculiarity of this group is to be found in the

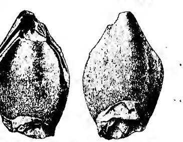


LEFT-SIDE VIEW OF AN IMPERFECT VERTEBRA OF A LIZARD-FOOTED DINOSAUR. (From the *Quart. Journ. Geol. Soc.*, 1893.)



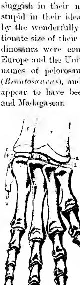
INNER AND LATERAL VIEWS OF A TOOTH OF A HOPLOSAUR.

circumstance that the vertebræ of the neck and back, as shown in the accompanying figure, had large cavities in their sides, which in the living state may have been filled either with cartilage or with air. These vertebræ resembled those of existing crocodiles, as described on p. 6, in having a ball at one end and a cup at the other; but whereas in crocodiles the ball is at the hinder end of the body and the cup in front, in these dinosaurs precisely the reverse of this arrangement obtained. As regards their dentition, these reptiles had their teeth implanted in distinct sockets, like crocodiles; but the teeth themselves, as shown in the accompanying figure, were of a peculiar spatulate shape, with the outer side convex and the inner concave. Agreeing in the general structure of their pelvis with crocodiles, these dinosaurs were distinguished therefrom by the circumstance that the bone known as the pubis (p in the figure on p. 3) enters into the composition of the cavity for the reception of the head of the thigh-bone. The limb-bones are solid throughout. From the nature of their teeth, which are often much worn by use, it may be inferred that these reptiles were vegetable feeders; and it is not improbable that they frequented the margins of lakes and rivers, where their inordinately long necks would enable them to browse with ease on the various aquatic plants. That they must have been very sluggish in their movements and stupid in their ideas is indicated by the wonderfully small proportionate size of their brains. These dinosaurs were common both in Europe and the United States, the larger forms having been described under the names of pelorosaurs (*Pelorosaurus*), atlantosaurs (*Atlantosaurus*), brontosaurs (*Brontosaurus*), and hoplosaurs (*Hoplosaurus*); among which the atlantosaurs appear to have been the most gigantic. They also occur in India, Argentina, and Madagascar.



INNER AND OUTER VIEWS OF A TOOTH OF A PELOROSAUR.
(From the *Quart. Journ. Geol. Soc.*, 1893.)

Carnivorous Group. The carnivorous dinosaurs, of which the megalosaur (*Megalosaurus*) is the best known example, differed from the preceding group in the form of their teeth, which were compressed and sickle-shaped, with sharp cutting, and frequently serrated edges. Their limb-bones also were hollow; while their vertebræ were likewise hollow internally, but had no lateral cavities, and the pelvis (figured on p. 3), although of the same general type as in the lizard-footed group, presented important points of distinction. In place of the short feet of the last-named group, the carnivorous dinosaurs had elongated foot-bones, terminating in sharp claws; the number of functional toes in the hind-foot varying from four to three. That they habitually walked on the toes of their hind-limbs, and not (as was the case with the lizard-footed group) on the whole foot, is evident from the structure of this part of the skeleton, and from the circumstance that the fore-limbs were considerably smaller than the hinder pair, it may be inferred that progression was at least frequently accomplished by the aid of the latter alone. The close approximation of the huckle-bone of the ankle to the lower end of the tibia foreshadows the complete

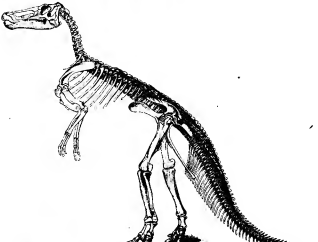


BONES OF THE RIGHT HIND-FOOT OF A CARNIVOROUS DINOSAUR.

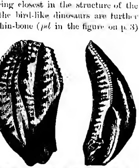
amalgamation which takes place between those bones in birds; while in one remarkable American form the metatarsal bones of the foot were reduced to three in number, and had nearly the same relationship to one another and to the bones of the ankle as obtains in birds. While the megalosaur attained a height, when erect, of some 15 feet, the little Compsognathus, of the lithographic limestones of Bavaria did not stand more than 2 feet; and there were other equally diminutive forms, both in England and the United States, in which the whole backbone was so permeated by air-cavities as to be little more than a mere shell of bone.

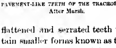
THE LEFT HUCKLE-BONE AND LOWER END OF TIBIA OF THE MEGALOSAUR.—After Gaudry.

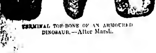
The Bird Like Group. The whole of the dinosaurs mentioned above agree with one another in possessing a pelvis approximating to the crocodilian type; that is to say, the pubis or anterior lower bone of this part of the skeleton is inclined downwards and forwards, and thus diverges in the form of an inverted *V* from the backwardly and downwardly directed ischium, or posterior lower bone, as shown on the figure on p. 3. On the other hand, in the bird-like dinosaurs the main


SKELETON OF THE CLAOSAURUS, ONE OF THE BIRD-LIKE DINOSAURS ($\frac{1}{24}$ nat. size).—After Marsh.

bar of the pubis is inclined backwards, parallel to the ischium, while it has a secondary plate projecting forwards. In this parallelism of the pubis and ischium these dinosaurs resemble birds (see the figure in Vol. III. p. 290), and birds alone; and from this and other features it is pretty certain that the latter are derived from reptiles more or less closely allied to this or the preceding group of dinosaurs; the resemblance in the one case being closest in the structure of the pelvis, and in the other of the hind-limb. All the bird-like dinosaurs are further characterised by the presence of a separate chin-bone (*pd* in the figure on p. 3) at the extremity of the lower jaw; by the absence of teeth from the front of both jaws; by the teeth themselves approximating more or less closely to the type of the one here represented, and by being frequently not implanted in distinct sockets; and likewise by the vertebræ being completely solid throughout. The typical representatives of this group are the well-known iguanodons, originally described on the evidence of teeth, from the Wealden rocks of England, but now known by entire skeletons from the corresponding deposits of Belgium, which are exhibited in the museum at Brussels. These reptiles, which were represented by allied forms in the United States, habitually walked on their three-toed hind-limbs, the largest individuals attaining a length of some 33 feet. They are characterised by the limb-bones being hollow, by the length of the metatarsal bones of the foot, by the first digit of the five-toed fore-limb being converted into a large conical spine, and also by the teeth being of the type of the one shown in the accompanying figure. Needless to say, animals with such teeth must have been purely vegetable feeders, as indeed were all the other members of this group. The hind-feet terminated in rather sharp claws, and there was no bony armour on the body. The iguanodons probably stalked about among the palm-forests of the Wealden period, on the leaves and fruit of which they may be presumed to have in great part subsisted. In these reptiles the large flattened and serrated teeth were arranged in each jaw in a single row, but in certain smaller forms known as trachodons, which occur in the higher Cretaceous rocks of both Europe and North America, there were several rows of teeth in use at the same time, the edges of these teeth being so flattened and fitted together that a pavement-like structure

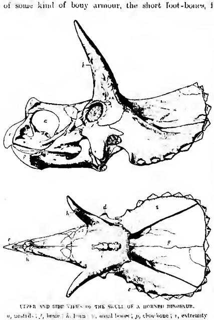

OUTER AND LATERAL VIEWS OF A TOOTH OF THE IGUANODON.


PAVEMENT-LIKE TEETH OF THE TRACHODON.—After Marsh.



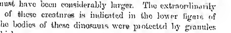
TERMINAL TOE-BONE OF AN ARMOURED DINOSAUR.—After Marsh.

resulted. These trachodons were all much inferior in size to the **gigantic** iguanodons. The American claosaur (*Claosaurus*), of which the skeleton is **figured** on p. 36, differs from the iguanodons in having the fore-paw of normal **structure.** Nearly allied to the iguanodons are the remarkable armoured and horned **dinosaurs,** which constitute a subgroup characterised by their solid limb-bones, the **presence** of some kind of bony armour, the short foot-bones, frequently terminating in hoof-like toes, and the habitually quadrupedal gait. Commencing in the British Lias, these extraordinary reptiles continued throughout the Secondary period, and seem to have attained their maximum development at the close of the Cretaceous epoch in the United States. Of the armoured forms, the huge stegosaur of the English Oxford, and Kimeridge Clays, and the corresponding rocks of the United States, was characterised by the possession of large quadrangular bones, which are believed to have been arranged in a vertical position down the middle of the back, while the tail was protected by some formidable spines, as shown in the greatly reduced restoration of the skeleton given on p. 4. Still more strange were the somewhat later horned dinosaurs (*Ceratops*, *etc.*), of which two views of the skull and a more reduced restoration of the skeleton are here given. In these extraordinary creatures the hinder part of the head was provided with a pair of bony horn-like projections, which were doubtless ensheathed during life with hollow horns, like those of oxen; and there was also a single horn of variable size on the nose. The skull was further remarkable for the expansion of its hinder extremity into a fan-like shield overhanging and protecting the vertebræ of the neck. Some idea of the huge dimensions attained by these dinosaurs will be conveyed by the



UPPER AND SIDE VIEWS OF THE SKULL OF A HORNED DINOSAUR.
n, nostrils; f, brain; h, horn; n, nasal bones; p, [illegible] bone; r, extremity of upper jaw.—After Marsh.

statement that an immature skull of one of the species measures upwards of 6 feet, while fully adult ones must have been considerably larger. The extraordinarily small size of the brain of these creatures is indicated in the lower figure of the skull. Externally the bodies of these dinosaurs were protected by granules and plates of bones, which, like those of crocodiles, were probably overlain with horny shields. It has yet to be mentioned that in the horned dinosaurs, as shown in the figure of the skeleton, the posterior bar of the pubis has disappeared, and only the front branch remains, thus causing the whole pelvis to simulate that of the carnivorous group, to which it has no real resemblance.



RESTORATION OF THE SKELETON OF A HORNED DINOSAUR.
pd, chin bone. Other letters as in the figure on p. [illegible].—After Marsh.

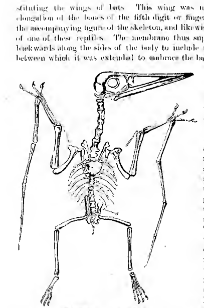
We have yet to learn the reason why, at the close of the Secondary period, these mighty dinosaurs, together with the flying dragons which at the same time tenanted the air and the fish-lizards and plesiosaurs which peopled the sea, should, one and all, disappear—and that apparently suddenly—to make way for mammals and birds, which henceforth became the lords of creation.

FLYING DRAGONS, OR PTERODACTYLES.

Order ORNITHOSAURIA.

At the present day bats and birds are the only Vertebrates endued with the power of true flight, but during the Secondary period, when the former were unknown and the latter but poorly represented, the place of both was taken by the flying dragons, or, as they are called, from the structure of their wings, Pterodactyles. While agreeing with crocodiles in the essential structure of their skulls and in their two-headed ribs, these curious reptiles have the other portions of their skeleton more or less specially modified for the purposes of flight. In the relatively large size of the brain—which is doubtless essential for a flying animal—and general bird-like form of the skull, as well as in the keeled breast-bone and general form of the collar-bones (although these are not welded together into a furcula), the pterodactyles present a curious similarity to birds. Misled by these resemblances, some anatomists have, indeed, been induced to consider that the two groups are nearly related, although a more mistaken notion never existed. Such resemblances as do exist between the two groups are due, indeed, to that parallelism in development to which we have already had occasion to call attention as existing between totally different groups of animals whose mode of life is similar.

The most distinctive feature of the pterodactyles is to be found in the modifications of the bones of the fore-limbs for the purpose of supporting a wing, which took the form of a membranous expansion of skin analogous to that constituting the wings of bats. This wing was mainly supported by the great elongation of the bones of the fifth digit or finger of the fore-limb, as shown in the accompanying figure of the skeleton, and likewise in the restored representation of one of these reptiles. The membrane thus supported seems to have extended backwards along the sides of the body to include the upper portions of the legs, between which it was extended to embrace the base of the tail in those forms in which the latter appendage was fully developed. Moreover, in the long-tailed species the extremity of the tail itself was provided with a racket-shaped expansion of membrane, which may have served the purpose of a rudder in flight. If it be asked how the presence of such membranes is known, it may be answered that in many of the specimens of these reptiles entombed in the fine-grained lithographic limestones of Bavaria the actual impressions of these membranes have been preserved. The elongated fifth finger of the wing had no claw at the extremity, although the three middle fingers were thus provided. With regard to the first finger, or the one corresponding to the human thumb, this may have been represented by the small splint-like bone seen depending from the wrist in the figured skeleton. The hind-limbs present no special peculiarities, but, as most of the bones of the skeleton were hollow and permeated by air, like those of birds, we may infer that the lungs were probably also constructed after the avian fashion. The vertebræ of the neck resembled those of living crocodiles in having a ball at the hinder end of the body and a cup in front. In general conformation the skull was remarkably bird-like, the snout being produced into a beak, which in some cases was provided with teeth, while in others, as shown in the figure on p. 5, it was toothless, and probably ensheathed during life with horn. Bird-like features are likewise shown by the large size of the brain-case, of which the component bones were fused together, and also by the union of the extremities of the two branches of the lower jaw.



SKELETON OF A PTERODACTYLE.

The creature is lying on its back, with the head bent to the left side; a indicates the left pubic bone; the haunch-bone, or ilium, being shown on the opposite side.

Pterodactyles flourished during the greater part of the Secondary period, dating from the epoch of the Lias, and continuing to the close of the one during which the

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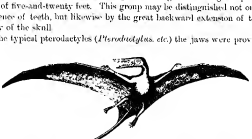
Chalk was deposited. They are represented by several well-marked types which may be arranged under three family groups. Of these the most specialised forms are the toothless pterodactyles, or pteranodonts, from the Cretaceous rocks of North America; some of these toothless members of the order far exceeded any flying bird in point of size; the estimated span of wing in the largest species being upwards of five-and-twenty feet. This group may be distinguished not only by the total absence of teeth, but likewise by the great backward extension of the hinder extremity of the skull.

In the typical pterodactyles (*Pterodactylus, etc.*) the jaws were provided with teeth,—which may, however, have been very small in size and few in number,—while the skull, as shown in the figure of the skeleton on p. 40, was not produced backwardly, and the tail was reduced to a rudiment. The members of this group, which are common in the Oolitic rocks of the Continent, vary in size from the dimensions of a sparrow to those of an eagle. Lastly, we have the long-tailed pterodactyles (*Rhamphorhynchus, etc.*), which are likewise of Oolitic and Liassic age, and are at once distinguished, as shown in the restoration, from the members of the preceding group by the fully developed tail. These long-tailed species are evidently the most generalised members of the order, and in the retention of the tail in the generalised group, and its loss in the more specialised one, the reader will not fail to notice an exact parallelism between ordinary bats and the more highly developed fruit-bats.

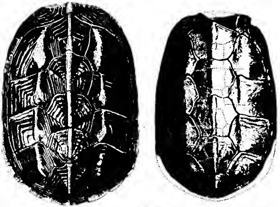


RESTORATION OF A LONG-TAILED PTERODACTYLE (⅓ nat. size).—After Marsh.

CHAPTER III.

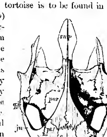
TORTOISES, TURTLES, AND PLESIOSAURS,—Orders CHELONIA AND SAUROPTERYGIA.

AMONG all existing reptiles the most easily defined are those commonly known as tortoises and turtles, and technically as Chelonians, since the presence of a more or less fully developed bony shell investing the body, and containing within it the upper portions of the limbs, at once separates them from all other members of the class. Indeed, so utterly strange is the conformation of these extraordinary reptiles, that if they were met with only in the fossil state they would inevitably be regarded as among the most marvellous of all creatures. Here however, as elsewhere, the time-honoured proverb holds good, and our very familiarity from childhood with the common European land-tortoise undoubtedly tends to render us inappreciative of the marvellous bodily conformation of this group of reptiles.



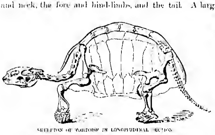
UPPER SHELL OF THE CHAIBASSA TERRAPIN, AND A FOSSIL SPECIMEN OF THE SAME IN WHICH THE HORNY SHIELDS ARE WANTING.

Although the presence of a bony shell is of itself sufficient to distinguish the group from other living reptiles, it is necessary to add somewhat to this in order to give a comprehensive definition. As regards the skull, this resembles that of the crocodiles, in that the quadrate-bone, with which the lower jaw articulates, is firmly wedged in among the adjacent bones, to which its relations are, however, somewhat different. Unlike all crocodiles the jaws are, however, entirely devoid of teeth and are encased with horn, so as to form a cutting beak, which is invariably short. A further peculiarity in the skull of a tortoise is to be found in the presence of a greatly developed median spine (*sup*) projecting backwards from the hinder region; externally to which are a pair of shorter processes. In other respects, the skull is extremely variable, the sockets of the eyes being sometimes, as in the figure on p. 47, surrounded by bone, while in other cases they are open behind. Sometimes, moreover, the bony roof behind the eye-socket in the figure on p. 47 may be prolonged backwards so as to cover the whole of the region marked *par* in the annexed figure. There is an equal amount of variation in regard to the position of the nostrils, which sometimes open on the palate close behind the beak, while they may be situated, as in living crocodiles, close to the hinder extremity of the skull. A most important feature in the structure of these animals is to be found in the circumstance that the ribs have but a single head apiece, and that the more anterior ones articulate at the junction between two of the vertebræ, so that one portion of the head is applied to one vertebra and the other portion to the adjacent vertebra. This forms an important distinction from the whole of the orders treated in the preceding chapter, in all of which the anterior ribs are provided with two heads, both of which articulate to the sides of one and the same vertebra. Passing on to the consideration of the bony shell, we find this to consist of an upper portion or carapace, shown in the figure at the commencement of the chapter, and of an inferior portion, covering the lower aspect of the body, which is termed the plastron. When this shell attains its fullest development, the upper and lower moieties are completely connected together, as shown in the accompanying figure of the skeleton of a land-tortoise; but in certain groups the two remain more or less separate, and in some cases the lower shell is but very slightly developed. Moreover, while the carapace is generally immovably welded to the vertebræ of the back and the ribs, in the so-called leathery turtle it is separate from both. In its fullest developed form, the shell consists of a series of bones articulating with one another at their edges, by finely denticulated sutures, and thus forming a continuous whole, capable of increasing in size by growth at the edges of its component elements. In the carapace, the bones forming the middle of the back are formed by expansions growing from the spines of the vertebræ, while the large lateral plates grow upon the ribs, from which they are inseparable. Within the cavity thus formed are placed the bones of the shoulder and pelvis, to which are



UPPER VIEW OF THE SKULL OF THE SOFT-TORTOISE OF THE GANGES.

respectively articulated the arm-bone and thigh-bone, so that, as shown in the figure of the skeleton, these bones actually come within the ribs instead of being external to them, as in all other living animals. At the fore and hinder extremities of the shell are left large apertures, through which are protruded the head and neck, the fore and hind-limbs, and the tail. A large number of tortoises are able to retract both the head, limbs, and tail within the margins of the shell, the apertures of which are then filled up; such portions of the head and limbs as are exposed being protected by horny shields.



SKELETON OF TORTOISE IN LONGITUDINAL SECTION.

With the exception of the marine leathery turtles and the fresh-water soft-tortoises, in which it is invested merely with a continuous leathery skin, the shell of Chelonians is covered with a number of horny plates, which, in the adult state at least, are in contact with one another by their edges. As these horny shields are very important in determining the different species of tortoises, it is essential to enter in some detail into their mode of arrangement, and the names by which they are known. In the carapace of any ordinary tortoise, such as the one represented in the left-hand figure at the head of the chapter, we shall find that the middle line of the back, exclusive of the margins, is occupied by a single row of large polygonal shields, symmetrical in themselves; these shields, which are marked *v* in the accompanying diagram, being known as the *vertebrals*. On either side of this median series is another row of shields *c*, which are not symmetrical in themselves, and are termed *costals*. The extreme margins of the carapace are formed by a large series of much smaller shields, of which the anterior unpaired one (*nu*) is termed the *nuchal* and the posterior (*cd*), which may be either single or double, the *caudal*. Between the nuchal and the caudal are a series, generally eleven in number on each side, designated *marginals* (*m*). These same marginal shields, being angulated, pass over the edges of the middle portion of the shell, and thus cover the sides of the middle of the plastron, or lower shell, as shown in the right-hand figure of the accompanying diagram. The shields of the plastron proper are generally arranged in pairs, which may be termed, commencing anteriorly, *gulars* (*gu*), *humerals* (*hu*), *pectorals* (*pc*), *abdominals* (*ab*), *femorals* (*fe*) and *anals* (*an*). In some cases, as will be illustrated in the sequel, the two gulars may, however, be separated by a single *intergular*; while, as in the accompanying diagram, there is frequently an inguinal shield immediately in advance of each notch for the hind-limbs.

This disposes of the external horny shields; but a few words are necessary with regard to the bony elements constituting the shell of a tortoise. On stripping off these horny shields from the carapace of a tortoise, the underlying solid shell, as shown in the right-hand figure at the head of the chapter, will be seen to be marked by a series of channels corresponding to the borders of these same shields. If the shell be not that of a very aged animal, there will be seen in addition a number of finely jagged sutures, marking the divisions between the component bones; and it will be noticed that in their plan of arrangement, although not in number, size, or shape, these underlying bones correspond very closely with the overlying horny shields. Thus, in the middle line of the carapace we have a series of polygonal plates, symmetrical in themselves, and attached to the summits of the vertebræ, which are known as *neurals*; these being clearly indicated in the figure referred to. In front, the series is completed by a large *nuchal* plate, having no connection with the backbone, while behind it terminates in one or two *pygals*,

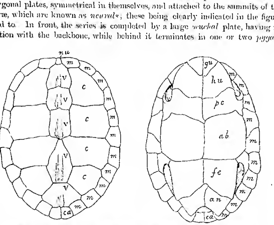


DIAGRAM OF THE HORNY PLATES ON A SHELL OF A FRESH-WATER TORTOISE.—After Günther.

which are likewise perfectly distinct from the vertebræ. Externally to the neurals are placed on either side the eight *costal* plates so named from being attached to the ribs; the inner halves of these plates being alone visible in the shell figured at the head of the chapter, which belonged to a rather aged animal. Finally, the edges of the carapace are formed by the *marginal* plates, which, like the horny shields similarly named, are angulated, and form the lateral borders of the middle portion of the plastron. In the plastron itself, we find its anterior portion formed by a pair of plates, known as the *epiplastrals*, corresponding to the collar-bones, or clavicles, of other Vertebrates; while between or behind these is a single unpaired *entoplastral* element, which may be either dagger-shaped or rhomboidal, and which represents the interclavicle of less specially modified reptiles. The remainder of the plastron is formed by three pairs of plates, respectively known as the *hyo*, *hypo*, and *xiphiplastrals*, of which the latter or hindmost are generally more or less deeply notched or forked. These three elements appear to correspond to the so-called abdominal ribs of crocodiles; and it will thus be evident that Chelonians have no representative of the breast-bone, or sternum, which is so commonly present in other groups of Vertebrates.

As regards their limbs, the members of this order present a great amount of variation, some of them, like the land-tortoises, having the feet adapted for walking, while in the turtles the entire limbs are modified into paddles for swimming. In some cases, each of the five toes may be furnished with strong, curved claws, but in others, like the soft-tortoises, only three are thus armed. As a general rule, the number of joints in the toes of the fore-limb, counting from within outwards, is 2, 3, 3, 3, 3, while in the hind-limb they are more generally 2, 3, 3, 3, 2, although in a few species the number is the same as in the fore-limb. In both limbs the number of these joints may, however, be reduced, but, except among the soft-tortoises, they are never augmented. Very generally, the surfaces of the limbs, especially the anterior ones of the front pair, are protected by horny plates of variable size, which, among the land-tortoises, may be underlaid by nodules of bone.

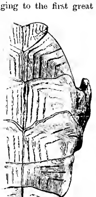
In habits the members of the order display as much diversity as in structure; some being carnivorous and others herbivorous, while some are marine, others fresh-water, and others, again, more or less exclusively inhabitants of dry land. All, however, are fond of water, and even the most strictly terrestrial species can, we believe, swim. With the exception of the turtles, the eggs are hard-shelled; and these are in all cases deposited on land, the turtles resorting to the shore at certain seasons for this purpose. As regards distribution, tortoises are especially characteristic of the warmer parts of the globe, only two species inhabiting Europe and these confined to the more southern parts of the Continent. The various groups and families are, however, by no means equally distributed over the different regions of the globe. The side-necked tortoises, for instance, are now exclusively confined to the Southern Hemisphere, and in Australia are the only representatives of the order; whereas the S-necked group attains its greatest development in the opposite half of the world, although represented in many countries lying to the south of the Equator. The soft river-tortoises, again, are confined to the waters of Asia, Africa, and North America, being totally unknown both in South America and in Australasia. Giant land-tortoises within comparatively recent times have been confined to what are known as oceanic islands, although they formerly occurred on most of the large continents; while the smaller members of the same genus are far more numerous in South Africa than they are in Asia. Geologically, the order is a very ancient one, being represented throughout the whole of the Secondary period, and thus commencing at a date when true crocodiles are not known to have come into existence.

According to our own views of their mutual relationships, the Chelonians may be divided into three main groups, or suborders, which may be severally designated S-necked tortoises (including the turtles), side-necked tortoises, and soft-tortoises. Some writers would, however, remove from the first group the so-called leathery turtle, to make it the type of a group equal in value to the whole of the other three, which are thus collectively brigaded under a common title. Adopting the former arrangement, we commence our survey of the various members of the order with

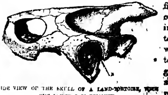
THE LAND-TORTOISES AND TERRAPINS.

Family *TESTUDINIDÆ.*

The land-tortoises, together with the greater number of the fresh-water tortoises, or terrapins, of the Northern Hemisphere, as well as their southern allies, collectively constitute one of several families belonging to the first great group of the order. From the circumstance that all its members are so constructed as to be able to withdraw their heads within the margins of the shell by a bending of the neck in an S-like manner in a vertical plane, the group may be conveniently designated S-necked tortoises; their scientific designation being *Cryptodira*. Since, however, the soft-tortoises likewise retract their heads in a similar manner, it is obvious that this character alone will not suffice to define the group, and it must accordingly be supplemented by others. Although the degree of ossification of the shell is very variable in the group, the carapace and plastron being in some cases welded into a complete box, and in other instances separate, yet there is invariably a complete series of marginal bones, connected with the ribs; the presence of the full series of marginals, together with the S-like retraction of the neck, being sufficient to distinguish the group. A peculiarity in which the members of the group differ from those of the next one, is to be found in the circumstance that the bones of the pelvis remain throughout life unconnected with the plastron; while in the greater number of cases the latter, as shown in the accompanying figure, comprises only six pairs of horny shields, their being no intergular shield between the first pair, or gulars. The skull is characterised by the tympanic ring (*t* in the accompanying figure) having a notch in its hinder border, and also by the condyle on its quadrate-bone fitting into a hollow at the hinder end of the lower jaw. This S-necked group includes the marine turtles, and all the tortoises of the Northern Hemisphere, with the exception of the soft river-tortoises, and thus comprises by far the greater number of the living representatives of the entire order. Although well represented in Africa and South America, the group is quite unknown in Australia.



THE LEFT HALF OF THE PLASTRON OF THE CHAIBASSA TERRAPIN.



SIDE VIEW OF THE SKULL OF A LAND-TORTOISE, WITH THE LOWER JAW REMOVED.

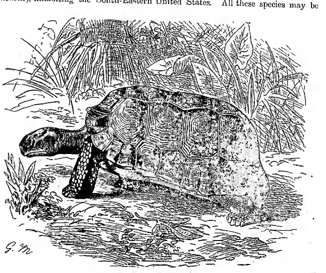
The land-tortoises and terrapins of the family *Testudinidæ* have the shell well developed and of a more or less oval shape; the plastron being connected with the carapace either by a straight articulation or by means of sutures, while it never has an intergular shield in front. The limbs are adapted more or less completely for walking, and are never modified into paddles; while the head is capable of complete retraction within the margins of the shell. A very important structural feature in the shell is that the nuchal or unpaired median bone in the front of the carapace, does not send back processes underlying the marginal bones of the same; while in the tail each vertebra has a cup in front of its body or lower portion, and a ball behind. None of the members of the family are marine, but while some are inhabitants of the land, others are more or less exclusively dwellers in fresh water. There are, moreover, equally important differences in regard to their food, all the land forms being herbivorous, while of those frequenting the water some subsist on vegetable, and others on animal substances.

Land Tortoises

By far the most numerously represented genus of the whole family is the one including the true or land-tortoises, of which there are rather more than forty existing species (counting a few that have been exterminated within the historic period). These tortoises, of which a few are more or less aquatic in their habits, have the upper and lower portions of the shell completely welded together, the former being frequently very convex and much vaulted; while the top of the head is covered with large horny shields. The limbs, which are entirely adapted for walking, are of a club-like form, and are covered with large horny scales or tubercles; their toes being unwebbed and furnished with strong, claw-like nails. The tail is always short, its proportionate length not being greater in the young than in the adult. More important characters are, however, furnished by the bony shell and skull, to observe the former of which it is of course necessary that the horny shields should be stripped off. In a shell thus treated it will be seen that the unpaired median neural bones of the carapace are relatively short and wide, and so arranged that a four-sided one is interposed between two that are octagonal, although in some cases they are mostly hexagonal; while the costal or lateral plates are alternately narrow above and broad below. Moreover, the line dividing the costal horny shields from the marginals usually corresponds with the suture between the corresponding bones of the carapace, whereas in the other members of the family one is above the other; while a further peculiarity of most species of the genus is that there is but a single caudal horny plate at the hinder end of the carapace. In the skull the palate is provided with one or two ridges on each side; while the hinder aperture of the nostrils is situated on the line of the eyes. It may be mentioned here that, as in the majority of the representatives of the order, the form of the shell differs considerably in the two sexes; the male having the central region of the plastron deeply concave, while in the females it is flat or slightly convex.

True tortoises are distributed over Southern Europe and Asia, the whole of Africa, the southern portions of North America, and South America (inclusive of the Galapagos Islands). They are strictly herbivorous in their diet; and certain species, now confined to oceanic islands, attain gigantic dimensions, and are by far the largest representatives of the family. The species inhabiting colder regions hibernate during the inclement season by burrowing in the ground, whereas those found in more genial climates are active throughout the year. All the species appear to be diurnal in their habits, and although they are all fond of water, the common European species always withdraws into its shell at the slightest shower. These reptiles will live to an enormous age, which, in some instances at least, may be reckoned by centuries. According to the classification adopted by Mr. Boulenger, the species of this extensive genus may be arranged under seven groups, of which we proceed to notice representative species.

Florida Tortoise. The land-tortoises of North America include three species, of which one of the best known is the Florida tortoise (*Testudo polyphemus*), inhabiting the South-Eastern United States. All these species may be



BRAZILIAN TORTOISE (¼ nat. size).

easily recognised by the anterior extremity of the palate of the skull having a median longitudinal ridge, instead of the deep pit characterising all other members of the genus. In the Florida tortoise, as well as in the allied Agassiz's tortoise (*T. agassizi*), the length of the shell is more than twice its height, while the beak is not hooked, and the fore-limb is broadest at its extremity. On the other hand, in Berlandier's tortoise (*T. berlandieri*), from Mexico and Texas, the shell is proportionately shorter, the beak is hooked, and the fore-limb widest at the elbow. These species are all of small size, not exceeding 10 inches in length.

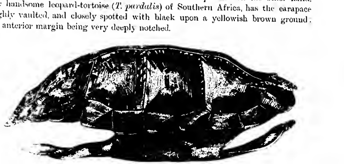
Brazilian Tortoise. The Brazilian species (*T. tabulata*), figured above, represents a group by itself, of which the distinctive characters are as follows. The carapace is much elongated and somewhat depressed, with its margins not everted; its general colour being dark brown or black, with a yellowish centre to each of the shields on the back. The nuchal shield of the carapace is wanting; while in the plastron the gular shields, although well developed, are prolonged anteriorly into horn-like processes. The head and limbs are marked with orange or red spots, on a dark ground. This handsome tortoise, which attains a length of nearly 22 inches, is an inhabitant of tropical South America, to the east of the Andes, and also of the Windward Islands, ascending to an elevation of about two thousand feet. In many wooded districts it appears to be very abundant, feeding not only on leaves and grasses, but likewise on the fallen fruit which is to be met with in great quantities. In the hot season it constructs a nest of dry leaves, wherein are deposited its eggs, which may be a dozen or two in number. When first hatched, the young are of a uniform yellowish brown colour, with their shells still soft. The young, and to a less degree the adults, have, according to the Prince of Wied, numerous enemies. Against the puma and jaguar the stout shell of even the adult seems to be no defence, since according to native reports, those animals, on finding one of these tortoises, will set it up on end and scoop out the flesh with their paws; while from the occurrence of broken shells in the forest it would seem that in some cases they are actually able to tear the plastron away from the carapace. As the flesh is devoid of smell, it is likewise eagerly sought after by both Indians and Portuguese, who are in the habit of keeping these tortoises—known in Brazil by the name of sciabuti—in stews, where they are fattened for the table. They are also allowed to run about the houses, where they are fed chiefly on plantains.

Burmese Brown Tortoise

The four species belonging to the third group, of which the Burmese brown tortoise (*T. emys*) is an example, are characterised by the presence of some very large conical, bony, spur-like tubercles on the lower portion of the hind-leg, and the circumstance that the length of the union in the middle line of the anal shields of the plastron is considerably less than that of the abdominal shields; the colour of the carapace in the adult being either uniform brownish, or yellowish brown closely spotted with black. The Burmese brown tortoise, which attains a length of 18 inches, while agreeing with the species above noticed in the possession of a nuchal shield on the front of the carapace, differs in that the caudal shield at the hinder extremity of the same is divided, as in the terrapins. The shell of this species is much depressed, with the anterior and posterior borders of the carapace serrated; the adult being dark brown, or blackish in colour, while in the young the carapace is yellowish brown, with dark brown markings. In addition to the spur-like tubercles on the back of the heel, the whole of the front of the fore-limb is overlain with imbricating bony tubercles, arranged in four or five longitudinal rows, and there are some conical ones on the back of the thigh, as well as others on the lower surface of the hind-foot. This species is an inhabitant of Assam, Burma, Siam, the Malay Peninsula, and Sumatra, where it frequents moist wooded districts, and is believed to be largely aquatic in its habits. The association of a divided caudal shield, with habits reputed to resemble those of the terrapins, is somewhat noteworthy.

In the other three members of this group the nuchal shield is wanting, and the caudal single. Of these, the Argentine tortoise (*T. argentina*) of South

America, and the spurred tortoise (*T. calcarata*) of Africa, are characterised by their flattened and uniformly brownish-coloured carapaces. On the other hand, the handsome leopard-tortoise (*T. pardalis*) of Southern Africa, has the carapace highly vaulted, and closely spotted with black upon a yellowish brown ground, its anterior margin being very deeply notched.

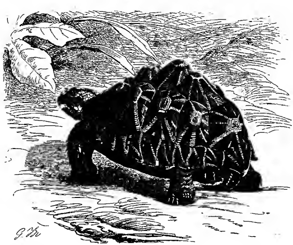


SIDE VIEW OF SHELL OF BURMESE BROWN TORTOISE.
(From Günther, *Proc. Zool. Soc.*, 1882.)

Elegant Tortoise.

The fourth group comprises about ten very beautifully coloured small, or medium-sized, tortoises, the great majority of which are confined to South Africa, although the species here figured (*T. elegans*) is an inhabitant of India and Ceylon. All these species are easily recognised by the carapace being extremely convex, and either black in colour, with yellow lines radiating from the centre of each of the shields of the back, or yellow, or brownish, marked with radiating black lines. Frequently, moreover, the shields of the back are swollen, so as to form more or less prominent bosses. The Indian species, together with an allied one (*T. platynota*), from Burma, is distinguished from all the other members of the group by the absence of the nuchal shield at the front of the carapace. Of the other eight species no less than seven are South African, while the radiated tortoise (*T. radiata*) is from Madagascar; one of the best known members of the group being the common geometric tortoise (*T. geometrica*) of the Cape, which attains a length of some 5½ inches. In the eyed tortoise (*T. oculifera*) the pectoral shields of the plastron may not meet in the middle line, as is the case in some individuals of the Burmese brown tortoise. While the elegant and geometric tortoise have the carapace black, with narrow yellow rays, in the eyed tortoise the markings take the form of brownish yellow and dark brown rays of nearly equal width.

An admirable account of the habits of the elegant tortoise is given by Capt. T. Hutton, from which the following extracts are made. These tortoises are fairly common in dry, hilly districts, where they inhabit the high grass-jungles at the foot of the hills. Nevertheless, they are by no means easy to find, owing to their colour and appearance harmonising so closely with the rocky ground, and from their habit of remaining in concealment beneath shrubs or tufts of grass during the heat of the day. They are tracked by the Bhils of Meywar to their hiding-places by following the trail of their footsteps in the dry sand; the same method being employed by some of the wild tribes of South Africa in the case of the allied species inhabiting that continent. In the rainy season the elegant tortoise is, however, extremely active, and wanders about in search of food at all hours of the day. At the approach of the cold weather these reptiles select a sheltered spot, where they conceal themselves by thrusting their shells into thick tufts of bushes or shrubs, in order to be better protected from the cold. There they remain in a kind of lethargic, although not truly torpid, state, till the hot season, when they issue out to feed only after sunset and in the early morning. Specimens kept in captivity were observed to be very fond of plunging into water during the hot season, where they would remain for half an hour at a time. They also drank large quanties of water at this period of the year, which they took by thrusting in their heads and swallowing in a series of gulps. About November the female lays her eggs in a shallow pit excavated by herself. One of the aforesaid captive specimens in the course of about two hours "succeeded in making a hole six inches in depth and four inches in diameter; in this she immediately deposited her eggs, four in number, filling up the hole again with the mud she had previously scraped out, and then treading it well in, and stamping upon it with her hind-feet alternately until it was filled to the surface, when she bent it down with the whole weight of her body, raising herself behind as high as



ELEGANT TORTOISE (⅓ nat. size).

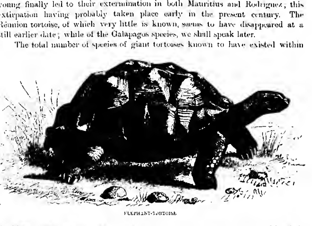
GIANT TORTOISES OF THE GALAPAGOS ISLANDS.

she could stretch her legs, and suddenly withdrawing them, allowing herself to drop heavily on the earth, by which means it was speedily beaten flat; and so smooth and natural did it appear that, had I not detected her in the performance of her task, I should certainly never have noticed the spot where she had deposited her eggs. She did not immediately leave the place after finishing her work, but remained inactive, as if recovering from her fatigues." In disposition these tortoises are decidedly pugnacious, this being especially the case with the males. These combats seemed to be chiefly trials of strength, "one male confronting the other, with the hind and fore-legs drawn into the shell, and the hind-feet planted firmly on the ground, and in this manner striving against each other until one or both became fatigued. This was done chiefly when they wanted to pass each other in any narrow space; and sometimes if the one could succeed in placing his shell a little beneath the other, he tilted him over on his back, from which he had great difficulty in recovering himself; and I have frequently found them sprawling thus, making desperate efforts with head and feet to throw themselves back to their natural position, which they were unable to effect unless the ground chanced to be very uneven, so as to assist them."

Giant Tortoises.

During the Pliocene, or later division of the Tertiary period, gigantic land-tortoises were, as attested by their petrified remains, widely distributed over the continents of the world; species having been obtained from India, France, and North and South America. The largest of these was the well-known atlas tortoise (*T. atlas*) from the Siwalik Hills of Northern India, in which the length of the shell was about 6 feet; the species itself being apparently allied to the existing Burmese brown tortoise already referred to. Probably more or less abundant during the epoch in question, with the advent of the ensuing Pleistocene epoch giant tortoises seem to have disappeared entirely from the continental areas, to survive on certain oceanic islands where they were free from the competition of large animals of higher organisation. Some of these insular species, like those of Madagascar and Malta, did not apparently survive the Pleistocene epoch; while in other regions they flourished and multiplied till the fell presence of man led to their partial or total extermination. At the present day the few survivors of these monstrous reptiles are being rapidly reduced in numbers, and unless special means be speedily taken for their preservation, they will ere long entirely cease to exist. During the historic period the islands where giant tortoises are known to have existed constitute three distinct groups. Two of these are situated in the Indian Ocean, and comprise Aldabra, to the north-west of Madagascar, and the Mascarene Group—including Réunion, Mauritius, and Rodriguez—lying to the east of the same; while the third or Galapagos Group, taking its name from the Spanish word for tortoise, is situated in the far distant South Pacific, off the western coast of South America. During the sixteenth and seventeenth centuries, the tortoises are stated to have existed in enormous numbers in all the above-named islands; but as they afforded a most valuable supply of food, and could be kept alive on board ship, their numbers were rapidly reduced in those of the Indian Ocean, and Aldabra is now the only island in that area where they still exist in a wild state. Many of these tortoises were, however, exported to the Seychelles, and it is believed, as we shall notice below, that one carried thence to the Mauritius is the only living example of the species that formerly inhabited Rodriguez. Regarding the abundance of these tortoises in the latter island, François Leguat, writing in 1691, observes that "there are such plenty of land turtles in this isle, that sometimes you see a three thousand of them in a flock, so that you may go above a hundred paces on their backs." In Mauritius they were still abundant in 1740, but about 1761 they were probably scarcer, as thousands were then imported from Rodriguez as food for the patients in the hospitals of the Mauritius. The continued exportation,—some ships taking as many as four hundred at a time,—coupled with the destruction of their eggs and young finally led to their extermination in both Mauritius and Rodriguez, this extirpation having probably taken place early in the present century. The Réunion tortoise, of which very little is known, seems to have disappeared at a still earlier date; while of the Galapagos species, we shall speak later.

The total number of species of giant tortoises known to have existed within the historic period is about fourteen: the whole of which are characterised by their large size, their long necks, and the uniformly dark brown or black colour of their shells. They may be divided into four groups, according to their geographical distribution, each characterised by certain structural peculiarities. The first group comprises the four Aldabra tortoises, characterised by the presence of a nuchal shield on the front of the carapace, and the distinctness of the gulars on the front of the plastron. On the other hand, in the four best known Mascarene species, constituting the second group, the nuchal shield is wanting, while the two gulars have coalesced into one: the plastron being characterised by its extreme shortness. Lastly, the third, or Galapagos group with six species, presents a condition intermediate between that existing in the two others, the nuchal shield of the carapace being absent, while the gulars of the plastron remain double. We proceed to notice some of the species of each group.



ELEPHANT-TORTOISE.

Aldabra Tortoise. The best known of the four species from Aldabra is the elephant-tortoise (*T. elephantina*), which differs from the other three in having the horny shields of the carapace concentrically striated, and the plastron of the adult notched behind. One of the species (*T. gigantea*) with smooth shields on a truncated plastron is peculiar in having the caudal shield divided, as in the Burmese brown tortoise. The elephant-tortoise appears to be one of the largest of all the species, attaining a length of about 4 feet. At the present day it is very scarce in its native island, where the few survivors receive a certain amount of protection from the Government of Mauritius, to which Aldabra belongs. There are, however, a few individuals living in Mauritius and the Seychelles.

Mascarene Tortoises. Of the Mascarene species, the three species from Mauritius (*T. indica*, *trisserrata*, and *inepta*), all of which are extinct, are characterised by the thinness of their carapace, of which the margins are thickened. The Rodriguez tortoise (*T. vosmari*) has a still thinner carapace, which in the male does not shelve down in front in the usual manner. Allusion has already been made to the numbers in which these tortoises existed in Leguat's time; but till quite recently it was thought that the species was totally extinct. It appears, however, that in the Artillery barracks of Port Louis in the Mauritius, there lives a very ancient tortoise which, in the opinion of Dr. Günther, is probably of this species. This tortoise is one of two which were imported into the Mauritius by the navigator, Captain Marion du Fresne from the Seychelles in 1766, one of these having been subsequently presented to the London Zoological Gardens in 1832 by Sir C. Colville. The latter weighed 289 lbs., and its shell measured 4 feet 4½ inches in length along the curve, and 4 feet 9 inches in width, while in the Port Louis specimen the circumference of the shell is 9 feet 3 inches, and its height 2½ feet. Marion's tortoise, as the Port Louis example is called, is thus definitely known to have lived for a hundred and twenty-seven years, and as it was doubtless of large size when brought from the Seychelles, and since all these tortoises take an immense time to reach large dimensions, it is highly probable that it is an actual survivor from the enormous herds that existed in Rodriguez in Leguat's time. From a peculiarity in the structure of the hinder vertebræ of the neck, it appears that the tortoises of this species have the power of raising their necks to a nearly vertical position, which would give them a wide range of vision. This elevated range of vision would accord well with the account given by Leguat, who writes concerning these tortoises as follows. "There's one thing very odd among them; they always place sentinels at some distance from their troop, at the four corners of the camp, to which the sentinels turn their backs, and look with the eyes, as if they were on the watch."

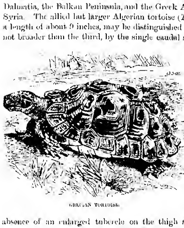
Galapagos Tortoises. The various islands of the Galapagos Group, such as Abingdon, Albemarle, Chatham, Hood, and Charles, are the respective homes of one or more species of giant tortoise. Of the various species inhabiting these islands, the blackish tortoise (*T. nigrita*), which is the one given in the illustration on p. 54, agrees with two others (*T. nigra* and *T. vicina*) in having the horny shields of the carapace concentrically striated in the adult: the figured species differing from *T. nigra* in having the plastron notched, instead of truncate behind. In the other three species the shields on the back are smooth, while the plastron always has its hinder end truncated. In the North Albemarle tortoise (*T. microphyes*), the width of the bridge connecting the upper and lower shells is of considerable length, and the shell itself stout. On the other hand, in the saddled tortoise (*T. ephippium*) and the Abingdon tortoise (*T. abingdoni*) the same bridge is relatively short, and the shell is remarkable for its thinness; the carapace being much narrowed anteriorly, where it is so pinched in at the sides as to have a sharp ridge on the back. In the former of these two species the shell still retains the usual bony framework, but in the second it is soft and leathery. Both have very long necks, which are carried nearly vertically; and in the Abingdon species the notches in the front end of the shell are so large that in a front view the animal appears merely to have a kind of mantle thrown over the body. It is hard to see what can be the object of this softening and atrophy of the shell, but it is quite clear that it renders the animals very liable to injury, and thus probably accounts for the fact that none of them have been brought alive to Europe. The carapace of this species attains a length of 38½ inches, and the weight of one individual was just over 200 lbs.

The best account of the habits of the Galapagos tortoises is one given by Darwin, regarding the species figured in our engraving, which inhabits, apparently, most of the islands of the group. These tortoises frequent in preference the high damp parts, although they likewise live in the lower and arid districts. Very numerous in individuals, some grow to such a size that it requires six or eight men to lift them, while they will yield as much as 200 lbs of meat. "The old males are the largest, the females rarely growing to so large a size; the male can be readily distinguished from the female by the greater length of its tail. The tortoises which live on those islands where there is no water, or in the lower and arid parts of the others, feed chiefly on the succulent cactus. Those which frequent the higher and damp regions eat the leaves of various trees, a kind of berry, which is acid and austere, and likewise a pale green filamentous lichen that hangs in tresses from the boughs of the trees. The tortoise is very fond of water, drinking large quantities, and wallowing in the mud. The larger islands alone possess springs, and these are always situated towards the central parts, and at a considerable height. The tortoises, therefore, which frequent the lower districts, when thirsty, are obliged to travel from a long distance. Hence, broad and well-beaten paths branch off in every direction from the wells down to the sea-coast; and the Spaniards by following them up, first discovered the watering-places. When I landed at Chatham Island, I could not imagine what animal travelled so methodically along well-chosen tracks. Near the springs it was a curious spectacle to behold many of these huge creatures, one set eagerly travelling onwards with outstretched necks, and another set returning after having drunk their fill. When the tortoise arrives at the spring, quite regardless of any spectator, he buries his head in the water above his eyes, and greedily swallows great mouthfuls, at the rate of about ten in a minute. The inhabitants say that each animal stays three or four days in the neighbourhood of the water, and then returns to the lower country, but they differed respecting the frequency of these visits." After mentioning that some tortoises live on islands where the only water they obtain is that which falls as rain, and also that the inhabitants of the Galapagos Islands, when overcome with thirst, are in the habit of killing a tortoise and drinking the water contained in its interior, the writer proceeds as follows:—"The tortoises, when purposely moving towards any point, travel by night and day, and arrive at their journey's end much sooner than would be expected. The inhabitants, from observing marked individuals, consider that they travel a distance of about eight miles in two or three days. One large tortoise, which I watched, walked at the rate of sixty yards in ten minutes, that is three hundred and sixty yards in the hour, or four miles a day,—allowing a little time for it to eat on the road. During the breeding-season, when the male and female are together, the male utters a hoarse roar or bellowing, which, it is said, can be heard at a distance of more than a hundred yards. The female never uses her voice, and the male only at these times; so that when the people hear this noise, they know that the two are together. They were at this time (October) laying their eggs. The female, where the soil is sandy, deposits them together, and covers them up with sand, but where the ground is rocky, she drops them indiscriminately in any hole: Mr. Bynoe found seven placed in a fissure. The egg is white and spherical; one which I measured was 7⅜ inches in circumference, and therefore larger than a hen's egg. The young tortoises, as soon as they are hatched, fall a prey in great numbers to the carrion-feeding buzzard (*Polyborus*). The old ones seem generally to die from accidents, as from falling down precipices, at least, several of the inhabitants told me that they never found one dead without some evident cause. The inhabitants believe that these animals are absolutely deaf: certainly they do not hear a person walking close behind them. I was always amused when overtaking one of these great monsters, as it was quietly pacing along, to see how suddenly, the instant I passed, it would draw in its head and legs, and uttering a deep hiss fall to the ground with a heavy sound, as if struck dead. I frequently got on their backs, and then giving a few raps on the hinder part of their shells, they would rise and walk away;—but I found it difficult to keep my balance."

Like their Mascarene allies, the Galapagos tortoises are much esteemed as food, and in order to see whether they were sufficiently fat to be killed, the inhabitants were accustomed to make a slit beneath the tail, through which the interior of the body could be seen. With the usual hardihood of reptiles, the rejected individuals appear to have recovered completely from this severe operation. From several of the islands the giant tortoises have already disappeared, and it is much to be feared that they will soon cease to exist throughout the Galapagos Group. Dr. G. Baur, who visited Albemarle in 1891, reports, however, that he made a large collection of these reptiles, one specimen weighing more than 400 lbs., and its carapace measuring 4 feet in a straight line.

Grecian Tortoise.

The familiar Grecian tortoise (*T. græca*) brings us to the sixth main group of the genus, which comprises seven Old World species of small or medium size, characterised by the carapace being brown or olive, which may be either uniform, or spotted with black, or black and yellow; by the gular shields on the plastron being distinct; and by the slight prominence and shortness of the ridge on the palate. The Grecian tortoise belongs to a section of the group in which the anal or hindermost shields of the plastron meet in the middle line by a suture of considerable length; and it is further characterised by the presence of five claws on the fore-foot. From its nearest allies it may be distinguished by the fifth vertebral shield of the [illegible] being much broader than the third, the caudal shield being usually double, and there being no large tubercle on the inner side of the thigh. The shell of this species is moderately vaulted, and not much expanded behind, while its margins are not serrated. The nuchal shield is very long and narrow; in the male the divided caudals are much incurved; and the shields of the back show a strongly-marked concentric striation. In colour, the shell is bright yellow, with the shields of the carapace spotted and bordered with black, and a broad band of black running along each side of the plastron. The length of the shell is about 5½ inches. Mainly a South European species, the Grecian tortoise inhabits the Balearic Islands, Corsica, Sardinia, Sicily, Italy, Dalmatia, the Balkan Peninsula, and the Greek Archipelago, while it also occurs in Syria. The allied but larger Algerian tortoise (*T. ibera*), in which the shell attains a length of about 9 inches, may be distinguished by the fifth vertebral shield being not broader than the third, by the single caudal shield, and the presence of a large subconical tubercle on the inner surface of the thigh. In colour, this species differs from the last in having the plastron more or less spotted with black, while in some examples the carapace is uniformly brown. Its range includes North-Western Africa, Syria, Asia Minor, Transcaucasia, and Persia. A third species often represented among the shiploads of these reptiles imported into England, is the margined tortoise (*T. marginata*), which attains a length of 11 inches, and appears to be confined to Greece. The absence of an enlarged tubercle on the thigh serves to distinguish it from the preceding species, from which it also differs by the longer and more depressed shell, in which the hinder margin is much expanded, and more or less serrated. Usually the carapace of the adult is black with a small yellow or greenish spot on each shield; while the ground-colour of the plastron is yellowish, each of its shields being marked by a black patch, which generally takes a triangular form. This species appears to be confined to Greece; but in Lower Egypt and Syria is replaced by the smaller Leith's tortoise (*T. leithi*), in which the carapace is relatively shorter and more deeply notched in front, while the form and arrangement of the tubercles on the fore-limb is different.



GRECIAN TORTOISE.

All these tortoises appear identical in their habits, frequenting dry and sandy places, and being extremely fond of sunshine, in which they will bask by the hour together. In certain parts of Greece and the south of Italy, the Grecian tortoise is found in great numbers; and in the markets of Sicily and Italy it is regularly exposed for sale as an article of food. At the approach of winter it buries itself deep in the earth, where it remains during the cold months, usually reappearing in

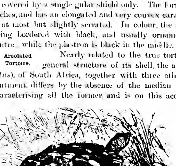
April, but in Sicily as early as February. Although its main food consists of plants and fruits, it will likewise consume such snails, worms, and insects as it may meet with during its wanderings. In captivity, where they have been known to live for a great number of years, these tortoises display great partiality for milky plants, such as lettuce; and they are always fond of a bath. At the approach of rain they always hide themselves, but in fine weather remain abroad throughout the day. In excavating a burrow for the winter's sleep, the earth is dug up by the strong fore-limbs, and thrown out from the hole by the hinder pair. The pairing-season commences immediately after the awakening from the winter sleep; and in May or June the female lays from eight to fifteen hard-shelled white eggs, of about the size of a hazel-nut. These are deposited in a hole in the earth in some sunny spot, and after being carefully covered up, are left to hatch. By September the young tortoises are about the size of half a walnut-shell, and present an exceedingly comic appearance.

Other Species. There are certain other species belonging to the same group as the Grecian tortoise, which demand a brief notice. Among these is the handsome elongated tortoise (*T. elongata*), from Bengal, Burma, Cambodia, and Cochin China, taking its name from the great length of the depressed shell of the males; the females being much smaller, with a relatively shorter and wider shell. These tortoises differ from the European species by the anal shields of the plastron having a very short line of union in the middle, even if they meet at all. The ground-colour of the shell is greenish yellow, upon which is an irregular black patch in each shield, which may occupy nearly the whole area of such shields, leaving merely a narrow yellow margin, or may be much broken up and indistinct. The male attains a length of between 10 and 11 inches. Forsten's tortoise (*T. forsteni*), from Celebes and Gilolo, may be distinguished by the want of a nuchal shield in the front of the carapace. Lastly, we have Horsfield's tortoise (*T. horsfieldi*), which, while allied to the European species, differs in having but four claws on the fore, as well as on the hind-feet. This tortoise inhabits the deserts, oases, and even mountains of Central Asia, where it ranges from the Aralo-Caspian region and the Kirghiz Steppes to Afghanistan. The shell, which is considerably depressed and not much longer than broad, has a brown or olive ground-colour above, which may be either uniform or blotched with black; while beneath, it has large patches of black, which sometimes almost cover the whole surface.

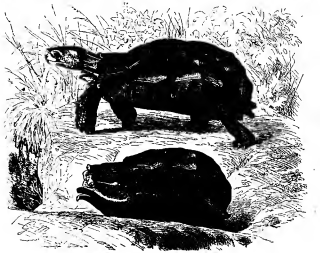
Writing of the elongated tortoise, Dr. J. Anderson says that it is active in its habits, and that the male is very confiding, eating readily from the hand, although the female, when touched, at once withdraws within the shell. Captive specimens were observed to be very restless at night; they feed freely on plantains, but a female on occasion ate some dead prawns and fish, which had been procured to feed some soft-tortoises. Horsfield's tortoise, although equally fond of immersing its lower shell in water, is said to be more brisk in hot weather than are the European species; it is purely diurnal in its habits, not venturing forth till after sunrise, and retiring to rest before sunset. Its food in the wild state is stated to be entirely of a vegetable nature; snails and worms being never eaten.

Angulated Tortoise. The angulated tortoise (*T. angulata*), of South Africa, together with an allied species (*T. yniphora*) from an island near the Comoros, constitute the last and seventh group of the genus, and are distinguished from all the others by the great prolongation of the anterior extremity of the plastron, which is covered by a single gular shield only. The former attains a length of about 7½ inches, and has an elongated and very convex carapace, of which the hinder margin is at most but slightly serrated. In colour, the shell is yellow above, each shield being bordered with black, and usually ornamented with a black spot in the centre while the plastron is black in the middle, or has some large black blotches.

Areolated Tortoise. Nearly related to the true tortoises, with which it agrees in the general structure of its shell, the areolated tortoise (*Homopus areolatus*), of South Africa, together with three other allied species from the same continent differs by the absence of the median ridge on the front of the palate characterising all the former and is on this account referred to a distinct genus. If the horny shields be stripped from the carapace, it will be found that the underlying neural bones, instead of being alternately octagonal and quadrangular, are irregularly hexagonal with the shorter of the two lateral surfaces placed posteriorly; since, however, the same feature occurs in some of the true tortoises, it is not absolutely characteristic of the genus. The areolated tortoise is a small species, with a shell of only 4 inches in length. It is characterised by having only four claws on the front feet, and by its depressed carapace, which is of equal width throughout, and has even margins. On the back, the shields are more or less inflated, and separated from one another by deep channels; the centre of each shield having a depressed areola, surrounded by concentric grooves. In colour, the carapace is olive, with a reddish brown centre to each shield while the plastron is brown in the middle, and yellow at the edges. A second species (*H. femoralis*) differs by having the hinder margin of the shell serrated, and a conical tubercle on the hinder surface of the thigh; while in a third (*H. signatus*), there are five toes on each fore-foot. Lastly *H. nogueyi* differs from all the others in its vaulted carapace which is gibbose behind; this species being from Senegal, while the other three are South African. In general habits it is probable that the members of this genus closely resemble the true tortoises.

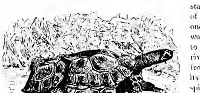

AREOLATED TORTOISE.

Hinged Tortoises Three remarkable tortoises inhabiting tropical Africa constitute a genus distinguished at a glance from the other members of this section of the family by the circumstance that the hinder portion of the carapace is articulated to the anterior moiety by a ligamentous hinge, upon which it is freely movable, so that when the animal is withdrawn the hinder extremity of the shell can be completely closed. This hinge runs between the fourth and fifth costal bones and the seventh and eighth marginals of the shell. The skull agrees with that of the preceding genus, in the absence of a median ridge on the front of the palate, while the neural bones of the carapace are hexagonal and short-sided behind, and the caudal shield is undivided. The costal bones of the carapace differ, however, from those of the tortoises described above, in being of nearly equal width throughout, instead of alternately narrow at one end and broad at the other. Of the three species of the genus, the dentated hinged tortoise (*Cinixys erosa*), from Guinea and the Gabun, is characterised by the front and hind margins of the carapace being everted and strongly dentated; by the absence of a nuchal shield, the projection of the extremity of the plastron in front of the carapace, and the sloping contour of the hinder extremity of the latter. The length of the shell is 9 inches; its general colour above being dark brown, with lighter centres to the shields, and the lower sides of the costal shields yellowish; while on the plastron the shields have dark brown centres and yellowish margins. In the nearly allied Home's hinged tortoise (*C. homeana*), from the same regions, there is a nuchal shield, the extremity of the plastron does not project in advance of carapace, and the hinder extremity of the latter descends vertically. On the other hand, Bell's hinged tortoise (*C. belliana*), which ranges right across tropical Africa, the margins of the carapace are neither everted nor serrated; a nuchal shield being present on the front of the carapace. In length the latter does not exceed 7½ inches.



DENTATED HINGED TORTOISES (½ nat. size).

In habits the hinged tortoises show a complete transition from the land tortoises to the terrapins, and thus fully justifies the conclusion, arrived at from structural considerations, that both groups should be included in a single family. According to the observations of Monteiro, it appears that Bell's hinged tortoise is essentially a land reptile, inhabiting regions formed of gneiss rocks or other dry localities, where it is active during the hot rainy season, but in the cooler portion of the year, from May to October, according to native reports, lies deeply buried in the earth. Both the other species, on the contrary, seem to be mainly aquatic in their habits; the dentated hinged tortoise, which is fairly common in Guinea, being stated to spend a large portion of its time in the water, where one specimen remained for upwards of a month. According to Falkenstein it is found in rivers, even close to the sea, from whence it emerges to lay its eggs on their banks. In spite of its club-like feet, it dives and swims with facility; captive examples descending to the bottom of a deep vessel in which they were kept. On land, its motions are, however, slow and deliberate in the extreme; and have been compared to those of the minute-hand of a clock. Its food is of a vegetable nature; one captive specimen displaying great partiality for cherries. By the inhabitants of Guinea these tortoises are eagerly sought after as food, and are thus difficult to obtain by Europeans.


BELL'S HINGED TORTOISE

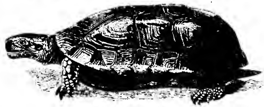
Spider-Tortoise. The last member of this section of the family is the spider-tortoise (*Pyxis arachnoides*) of Madagascar, which is the sole representative of a genus characterised by the presence of a transverse hinge across the front of the plastron, by which means the anterior lobe of the latter can be bent upwards so as to close the front of the shell. In having the neural bones of the carapace alternately octagonal and tetragonal, this species approaches the true tortoises nearer than do the hinged tortoises. In length the shell is only just over 4 inches; its coloration is yellow, with radiating black bands from the centres of the shields of the back.

Land-Terrapins. The whole of the tortoises hitherto described are collectively characterised by the absence of all trace of webbing in the toes, by the presence of not more than two joints, or phalanges in each toe, by the metacarpal bones of the fore-foot being but slightly, if at all, longer than wide, and also by the majority of the bony neural plates of the carapace being hexagonal, with their shorter lateral surfaces posteriorly placed, or alternately octagonal and tetragonal. On the other hand, in the remaining members of the family, the digits are usually furnished with webs, or at least a rudiment thereof, while the middle toe of each foot has three joints, and the metacarpal bones are elongated. We have first to deal with a small group, mainly confined to the Oriental region, which both in structure and habits tends to connect this section of the family with the preceding one. These forms, as shown in the right-hand figure of the illustration on p. 42, agree with the hinged tortoises in that most of the hexagonal neural plates of the carapace have the shorter of the two lateral surfaces placed posteriorly and the longer anteriorly. Moreover, if the horny shields from the plastron be removed, it will be found that the entoplastral, or median unpaired bone of that part of the skeleton, is crossed by the groove marking the boundary between the humeral and pectoral shields.

Spinose Land-Terrapin. The spinose land-terrapin (*Geoëmyda spinosa*) may be taken as a well-known example of the first genus, characterised by the absence of a hinge in the plastron, and of a bony temporal arch on the sides of the skull. The three species of this genus are large-sized tortoises, confined to Burma and the Malayan region; the spinose land-terrapin having a shell of 8 inches in length, while that of the great land-terrapin (*G. grandis*), from Burma and Siam, measures upwards of 16 inches. In the former of these two species both the front and hinder margins of the shell are deeply serrated; whereas in the latter, as well as in the third representative of the genus, only the hinder border is thus ornamented. The colour of the carapace in these terrapins is brown or blackish, frequently with darker markings. Together with the other members of the group, they differ from the majority of the terrapins in having the head covered with a continuous skin, instead of with small shields. The small size of the webs of these terrapins indicates that in habits they are probably in part aquatic and in part terrestrial.

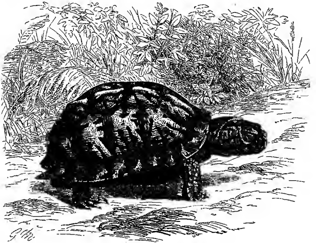
Chaibassa Terrapin. The Chaibassa terrapin (*Nicoria tricarinata*) figured in the illustration on p. 66, and taking its name from a district in Bengal, is selected to represent a genus common to the Oriental region in the east, and Central and South America in the west, distinguished from the preceding by the presence of a bony temporal arch to the skull. Of the seven species of this genus, the smallest (here figured) has a shell of only 5 inches in length, but in a larger one it may measure as much as 16 inches. While in the figured Chaibassa terrapin both fore and hinder margins of the shell, as shown on the left-hand figure on p. 42, are entire, in other species either one or both of these may be deeply serrated. The Chaibassa species, which ranges from Bengal to Assam, has the carapace dark brown or black in colour, with the three longitudinal ridges from which it takes its name yellow; the plastron being uniformly yellow, and the neck and limbs blackish. From the larger three-keeled terrapin (*N. trijuga*), of India and Burma, this species is further distinguished by its more convex shell, which descends very abruptly behind, as well as by the rudimentary condition of the webs between the toes; on both of which grounds it may be regarded as more exclusively terrestrial in its habits. A fossil shell of the Chaibassa terrapin, represented in the right figure on p. 42, has been obtained from the Pliocene rocks of the Siwalik Hills of Northern India, thus indicating the extreme antiquity of the species. In some individuals the hinder half of the plastron is connected with the upper shell merely by ligament.

Hinged Terrapins. The third genus of this group (*Cyclemys*), which is confined to India, Malayana, and the south of China, is represented by some half a dozen species, which, while agreeing with the members of the foregoing genus in the presence of a bony temporal arch to the skull, differ by having a well-marked transverse ligamentous hinge across the middle of the plastron, whereby its hinder lobe is rendered movable, and capable of more or less completely closing the posterior aperture of the shell. None of the species have a shell of more than 8 inches in length. The genus may be subdivided into two groups, each containing three species. In the former, as represented by *C. dhor*, of Northern India and the Malayan region, the plastron, which is notched behind, cannot completely close the shell; while the hinder margin of the carapace is serrated. In the second group, on the other hand, of which the Amboyna hinged terrapin (*C. amboinensis*) is a familiar example, the plastron is capable of completely closing the hinder aperture of the shell, while the posterior margin of the carapace is not serrated. These species also have the shell keeled on the back in the young state. In the Amboyna species, as also in *C. flavomarginata*, the hinder end of the plastron is entire, although in a third (*C. trifasciata*) it is notched.



CHAIBASSA TERRAPIN (⅓ nat. size).

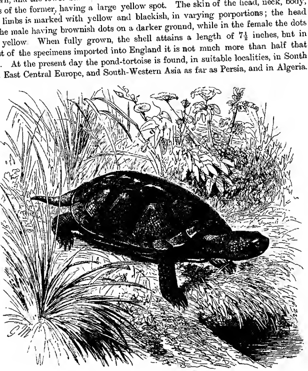
Box-Tortoises. Agreeing with the hinged terrapins in the presence of a transverse ligamentous hinge across the middle of the plastron, by the aid of which the openings of the shell can be closed, the two North American species of box-tortoises, together with all the remaining members of the family, differ from the former in that the hexagonal neural bony plates of the carapace have the shorter of their two lateral surfaces placed anteriorly, instead of posteriorly, this arrangement being shown when the shell is stripped. The presence of the hinge in the plastron serves to distinguish the box-tortoises from all the members of the second group, with the exception of the pond-tortoises, while from the latter they are separated by the beak being hooked, and the absence of a bony temporal arch to the skull. In the box-tortoises the head is covered with smooth skin above, the toes having only a rudimental web, and the tail is short. The Carolina box-tortoise (*Cistudo carolina*) is a somewhat variable species as regards size, the length of the shell ranging from a little over 4 to somewhat more than 5 inches. The highly convex carapace is almost hemispherical in shape, and is attached to the plastron solely by ligament, so that the whole shell can be completely closed. As a general rule, the upper shell is dark brown or blackish, with yellow spots, or brownish yellow, with dark brown spots or rays, while there may be an interrupted yellow streak down the middle of the back. The plastron may be either a uniform dark brown or blackish, or may have irregular yellowish blotches on a ground of the same, while in some instances it is yellowish with dark blotches of variable size. The range of this species embraces the Southern and South-Eastern United States and Mexico. In the ornate box-tortoise, from Nebraska and some neighbouring states, the shell is more depressed, and the plastron and carapace are connected together by a very short bony bridge, so that the shell cannot be completely closed. The toes, moreover, have no distinct webs.



CAROLINA BOX-TORTOISE (½ nat. size).

The vaulted carapace of the box-tortoises, with their abruptly descending hinder profile, together with the rudimentary condition of the webs of the toes, at once proclaim the terrestrial habits of these reptiles, which form, indeed, one of the connecting links between the true tortoises and the fresh-water terrapins. Although mainly, if not entirely carnivorous (as is indicated by the absence of a median ridge in the front of the palate), the box-tortoises appear to resemble the true tortoises very closely in their general mode of life. According to some observers, they are more frequently to be met with in dry and even hilly districts, than in swamps. They are, however, partial to spots where colonies of night-herons are in the habit of nesting, owing to the quantity of insects, snails, w and fragments of fish to be met with in such localities; and they are frequently found in woods where the ground is either moist or swampy. At times they will, however, enter the water of their own free will; and they have been seen half-buried under loose earth or moss in search of worms and insects. Unlike most members of the family, the box-tortoises shun the light, and are most active during the evening and night, shutting themselves closely up in their shells when the sun is shining brightly. The closure of the shell is also effected at the approach of any large animal; and when thus securely boxed up, there are but few creatures these tortoises need fear. Like most other terrestrial tortoises, the females lay their eggs in holes dug in the ground by themselves, the number laid being usually only five or six, whether the parents be half grown or adult. Each individual egg is carefully covered with earth, the time taken before the young are hatched being said to vary from eighty-eight to a hundred days. When first hatched, the young are well developed, and of great relative size and strength; although their shells are still soft and cartilaginous, and the remnant of the yolk-sac depends from the plastron. In Pennsylvania both young and old bury themselves deep in the ground about the middle of October, where they remain till the latter part of April; the spot selected having a dry soil, and being protected from the cutting blasts of the north. Many individuals which have not buried themselves sufficiently deeply, are, however, frozen to death during the winter slumber. On account of the strong and disagreeable flavour of their flesh, doubtless engendered by the nature of their food, the box-tortoises are not eaten.

Pond-Tortoises. In marked contrast to the vaulted and abruptly-descending carapace of the box-tortoises, is the depressed and shelving shell of the pond-tortoises; this difference indicating a distinction in the habits of the two genera. Thus whereas the box-tortoises are, as we have seen, mainly land reptiles, the pond-tortoises are as decidedly aquatic in their mode of life. In addition to the difference in the form of the shell, the members of the present genus are readily distinguished from those of the last by the beak not being hooked, and by the presence of a bony temporal arch in the skull. In the shell the carapace is united to the plastron solely by ligament, while the plastron itself is more or less distinctly divided by a ligamentous transverse hinge, upon which its two lobes are movable. Agreeing with the box-tortoises in having the top of the head covered with undivided skin, the pond-tortoises differ by having the toes fully webbed, and also by the more elongated tail, which, while very long in the young, is of moderate length in the adult. Although the genus *Emys* was formerly made to include many of the fresh-water terrapins, it is now restricted to the European pond-tortoise (*E. orbicularis*), and a nearly allied North American species. The former, which is familiar to most visitors to Southern Europe, is characterised by the short oval form of its carapace, which is widest posteriorly, and in the young state has a more or less distinct median keel. In colour, the upper shell of the adult is dark brown or black, ornamented with a variable number of light, usually yellow, dots or radiating streaks; the plastron being either yellow, brown and yellow, or almost wholly blackish brown. In the young, however, the upper shell is dark brown, and the lower black; all the shields of the latter, as well as the marginal ones of the former, having a large yellow spot. The skin of the head, neck, body, and limbs is marked with yellow and blackish, in varying porportions; the head of the male having brownish dots on a darker ground, while in the female the dots are yellow. When fully grown, the shell attains a length of 7½ inches, but in most of the specimens imported into England it is not much more than half that size. At the present day the pond-tortoise is found, in suitable localities, in South and East Central Europe, and South-Western Asia as far as Persia, and in Algeria.



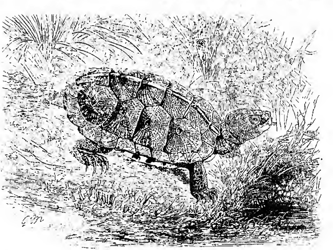
EUROPEAN POND-TORTOISE (⅖ nat. size),

During the Pleistocene period, when the climate of Northern Europe must at certain times have been much more genial, the pond-tortoise had a much more extensive distribution, its fossilised remains having been found in the superficial deposits of Belgium, Denmark, Germany, Lombardy, Norfolk, Sweden, and Switzerland. The American species, which inhabits the north-eastern United States and Canada, has the carapace rather more elongate, and the tail shorter; the former being black with pale yellow or brownish circular spots, and the plastron yellow with a large black patch on each shield.

The European species inhabits both stagnant and running waters, and may be found alike in slow or swift flowing streams, or in open lakes. During the day-time it leaves the water to bask in the sun on sequestered spots of the banks, where it remains without moving by the hour together, but towards sunset it begins to move, and remains active throughout the night. At the commencement of winter it constructs an underground chamber, in which it remains buried in slumber till spring, usually reappearing, if the weather be favourable, about the middle of April; at which time it reveals its whereabouts by a peculiar whistling cry characteristic of the breeding-season. An excellent swimmer and diver, the pond tortoise disappears beneath the water at the slightest sound, while when on land its motions are far more active than those of the true tortoises. Agreeing with other carnivorous terrapins in the absence of a median ridge on the fore-part of the palate, this tortoise feeds chiefly upon worms, water-insects, crustaceans, frogs, newts, tadpoles, and fish. In devouring fish, they reject the air-bladder, which floats on the surface of the water; and from the number of such floating air-bladders some idea may be formed as to whether a pond is numerously tenanted by these tortoises. In captivity, where they will live for years, pond tortoises in addition to their natural food will readily eat raw meat; and in this state they frequently become so tame as to take food from the hands of their masters. The eggs, varying from nine to fifteen in number, are laid at night during May in hollows dug by the female in dry soil, at a considerable elevation above the bank, where they are carefully covered up and left to develop. These tortoises are eaten by the inhabitants of all the countries in which they occur.

Terrapins. The remaining members of this extensive family, which may be collectively known as terrapins, and can receive but brief mention, have the plastron without any transverse hinge, and firmly connected by bone with the carapace, so that the whole shell is solid and immovable. They comprise a large number of species, arranged under eleven genera, and all that can be attempted in a work of the present nature is to select for special notice one or more species of such genera. Although many of these terrapins are exceedingly unlike one another externally, yet they are all so closely connected that the genera can only be distinguished by the characters of the skull and the bony plates of the shell, so that our description must of necessity be somewhat technical.

Sculptured Terrapin The sculptured terrapin (*Clemmys insculpta*), of eastern North America, is selected as a fairly well-known representative of a genus of eight species. This genus, it must be premised, forms one of a group of four agreeing with the two last noticed in the absence of a longitudinal ridge on the fore part of the palate, and in the carnivorous habits of its various members. From the three allied genera, *Clemmys* may be distinguished by the aperture of the inner nostrils in the skull being situated between the eyes, by the unpaired entoplastral bone of the lower shell being traversed by the groove formed by the junction between the humeral and pectoral shields, and by the upper part of the head being covered with a continuous smooth skin. The figured species belongs to a group of five, characterised by the median union of the anal or hindmost shields of the plastron being longer than that between the femoral shields; and while four species of this group are confined to North America, Beale's terrapin (*C. bealei*), inhabits China, thus showing a distribution analogous to that of the alligators. On the other hand, the Caspian terrapin (*C. caspica*), ranging from the Caspian Sea to the Persian Gulf, the Spanish terrapin (*C. leprosa*), of Spain and North-Western Africa, and the Japanese terrapin (*C. japonica*), resemble one another in having the median union of the anal shields shorter than that of the femorals. The sculptured terrapin, which attains a length of about 7 inches, is specially characterised by the toes being webbed only at their bases, by the upper jaw having a notch in the middle, on the sides of which are a pair of tooth-like projections, and by the serration of the hinder border of the carapace. The shell is much depressed, with a raised keel down the middle of the back, and the shields of the carapace ornamented with the radiating and concentric striæ from which that species takes its name.

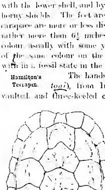


SCULPTURED TERRAPIN (⅔ nat. size).

While the ground-colour of the carapace is blackish, the radiating lines are yellow; the plastron being yellow, with a large black blotch on each of its shields. The soft parts are dark brown or olive, the sides of the head being speckled with red. The figured species is exceedingly abundant on the Atlantic side of the United States, from Maine to Pennsylvania and New Jersey. Frequenting both marshes and rivers, it leaves the water for much longer periods than its European congeners, and is sometimes found for months at a time in perfectly dry places. In wandering from one stream to another, it makes regular tracks through the woods, and is hence frequently termed in America the wood-terrapin. In its feeding and general mode of life this terrapin presents no features distinguishing it from other carnivorous kinds.

Thick-Necked Terrapin. Nearly allied to the preceding is the thick-necked terrapin (*Bellia crassicollis*), from Tenasserim, Siam, the Malay Peninsula, and Sumatra, which, with a second species from Borneo, constitutes a genus distinguished by the greater development of the bony buttresses connecting the upper with the lower shell, and by the hinder part of the head being covered with small horny shields. The feet are fully webbed, and the anterior vertebral shields of the carapace are more or less distinctly balloon-shaped. The typical species measures rather more than 6½ inches in length; and is of a general dark brown or black colour, usually with some yellow markings on the plastron, and some large spots of the same colour on the head. Several representatives of this genus are met with in a fossil state in the Pliocene deposits of North-Western India.

Hamilton's Terrapin. The handsomely coloured Hamilton's terrapin (*Damonia hamiltoni*), from India, conspicuous for its black and yellow, highly vaulted, and three-keeled carapace, is the best known representative of a third genus distinguished from the foregoing by the hinder aperture of the nostrils opening behind the line of the eyes and the great breadth of the palate. Like the two preceding genera, the entoplastral bone of the plastron is traversed by the groove formed by the union between the humeral and the pectoral shields; and the hinder part of the head is covered with small shields. Hamilton's terrapin has the elevated carapace marked with three interrupted longitudinal keels or rows of nodose prominences; the colour of the shell being dark brown or blackish, upon which are spots and streaks of yellow, and the soft parts having likewise a similar coloration. While in young individuals the hinder border of the carapace is strongly serrated, in the adult it becomes nearly smooth. This species attains a length of nearly 9 inches at the present day, but fossil examples found in the Pliocene rocks of Northern India were still larger. These fossil specimens lived with numbers of mammals belonging entirely to extinct species. There are four other species of the genus, ranging over Malayana, Southern China, and Japan.

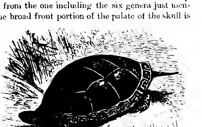

UPPER SURFACE OF CARAPACE OF HAMILTON'S TERRAPIN.

Salt Water Terrapin. The last representative of the group with a smooth palate and carnivorous habits is the North American genus *Malacoclemmys*, distinguished from the last by the head being covered with continuous skin, and by the groove formed on the plastron by the junction between the humeral and pectoral shields being situated in advance of the entoplastral bone. While two of the species inhabit the valley of the Mississippi, the salt-water terrapin (*M. terrapin*) is a frequenter of the salt-marshes of the Atlantic Coast. The latter has an oval and much depressed carapace, which attains a length of nearly 7 inches, and is characterised by the great width of the first and second vertebral shields; its general colour being either olive, with black concentric lines, or uniform blackish. The plastron is yellowish or reddish, with variable black markings.

It is this species that generally forms the celebrated New York dish known as terrapin; but it would seem that other species are also used, as the following account refers to terrapins taken high up the rivers. The best terrapins go by the name of "diamond-backs," and do not generally exceed some 7 inches in length, although they may rarely measure as much as 10 inches, but all terrapin of larger dimensions belong to the inferior kinds, ordinarily designated "sliders." According to Mr. W. M. Laflan, "terrapin are caught all the way from Savannah and Charleston to the Patapsio River at Baltimore, but the genuine diamond-back belongs only to the Upper Chesapeake and its tributaries. The majority of the sliders are brought to Baltimore from the James River. The terrapin-catchers make from five to twenty dollars per week, and they find the reptile, or 'bird,' as the *bon vivant* calls it, by probing the mud in the shallows with sticks. The terrapin is dormant, and when found is easily secured. A 4-lb. terrapin taken about September 15th will exist prosperously in a dark, cool place, without food or drink, until April 15th, and (the dealers say) will gain two ounces in weight. After that time it gets lively and active, and will take hold of a finger with great effusion and effectiveness. The male terrapin is known as a 'bull,' and the female as a 'cow.' The latter is much more highly prized, and generally contains about thirty eggs. No dish of terrapin is thought complete without being garnished with these." Formerly caught in shoals, the diamond-back has now become very scarce, and is, indeed, in some danger of extermination. The terrapin furnished in hotels is almost invariably "sliders," diamond-backs being sold to private houses only.

Painted Terrapin.

The seven remaining genera of the family constitute a distinct group, distinguished from the one including the six genera just mentioned by the circumstance that the broad front portion of the palate of the skull is marked by one or two longitudinal ridges, and likewise by all the species being mainly or exclusively herbivorous in their diet. Among these, the large and exclusively American genus *Chrysemys*, with a dozen species, of which the painted terrapin (*C. picta*) is one of the best known, belongs to a subgroup of three genera, characterised by the bony buttresses connecting the upper with the lower shell being short or of moderate size. From its allies *Chrysemys* is distinguished by the opening of the posterior nostrils being situated between the eyes, and by the entoplastral bone being situated in advance of the groove on the plastron formed by the junction of the


PAINTED TERRAPIN.

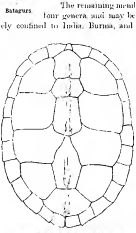
humeral with the pectoral shields. The painted terrapin of Eastern North America, which attains a length of 6 inches, and has a much depressed shell, takes its name from its brilliant coloration. Thus, the carapace is olive or blackish, with yellow lines bordering the shields, and its marginal shields red, with black concentric or crescentic markings, while the plastron is yellow, sometimes with small streaks of black on the middle line and the bridge red, with black markings. The soft parts have a brown or blackish ground-colour, with lighter bands, which are yellow on the head and red elsewhere.

Eyed and Chinese Terrapins

The eyed terrapin (*Morenia ocellata*), from Burma, together with an allied species from Bengal, constitute a genus distinguished from the preceding by the aperture of the posterior nostrils opening behind the line of the eyes. The typical species, in which the shell measures nearly 9 inches in length, takes its name from the eye-like black spots ringed with yellow which adorn each shield of the back portion of the carapace. On the other hand, the Chinese terrapin (*Ocadia sinensis*), which is the sole existing representative of its genus, differs from *Chrysemys* in having the entoplastron intersected by the groove formed by the junction between the pectoral and humeral shields. The genus is of special interest as being represented by extinct species in the upper Eocene strata of the south of England and the Continent.

Batagurs

The remaining members of the family, which are arranged under four genera, and may be collectively known as batagurs, are exclusively confined to India, Burma, and the Malayan region. They comprise the largest fresh-water representatives of the family, and are readily characterised by the great development of the vertical bony buttresses connecting the carapace with the plastron, which project as walls within the shell, so as partially to divide it into compartments. Of the four genera, *Cachuga*, which is represented by seven species from India and Burma, is readily recognised by the great elongation of the fourth vertebral horny shield of the carapace, which extends over four or five of the underlying neural bones. The smaller members, such as Smith's batagur (*C. smithi*), and the black-and-yellow batagur (*C. tectum*), of the Ganges and Indus, are characterised by the fourth vertebral shield terminating in front in a narrow point. Whereas the former of these has a depressed and feebly keeled shell, the latter, especially when young, has the carapace much vaulted, and the third vertebral shield produced behind into a conical elevation forming the highest part of the shell. The name of black-and-yellow batagur is derived from the irregular



UPPER SURFACE OF CARAPACE OF SMITH'S BATAGUR ([illegible] nat. size)

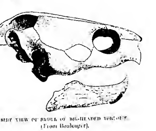
STOCK
1995

black patches on the bright yellow plastron; the carapace being brown. I have taken specimens of this pretty little batagur, which does not exceed 8 inches in length and is generally much smaller, near the fort at Calcutta. Like the under-mentioned dhongoka, it occurs fossil in the Pliocene deposits of Northern India. The larger species of the genus, such as the Indian dhongoka (*C. dhongoka*), which grows to over 14 inches, has the fourth vertebral shield broad in front, instead of being narrowed to a point. The three remaining genera, *Callagur*, *Batagur*, and *Hardella*, differ from the preceding in that the fourth vertebral shield of the carapace is not longer than the third; but it will be unnecessary to point out the features by which they are severally distinguished. The largest of all is the true batagur (*Batagur baska*), in which the carapace measures upwards of 20 inches in length.

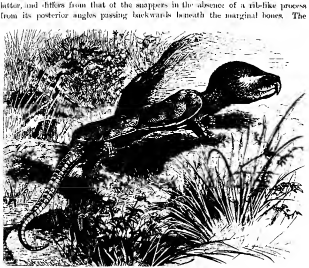
All the batagurs are exclusively vegetable feeders, and the larger species are thoroughly aquatic in their habits, spending by far the greater portion of their time in the water. They abound in the larger rivers of India and Burma, where their huge shells form conspicuous objects as they rise to the surface to breathe. Describing the habits of a captive specimen, Dr John Anderson states that when it rose to breathe "its nostrils were simply protruded above the surface of the water and retained in that position for about half a minute, during which it made a long expiration, followed by a deep inspiration, the creature then slowly paddling, tail-backwards, to the bottom. The animals, unless they were much irritated, never attempted to bite, but, when so treated, they sluggishly seized any object put in their way, holding it between their jaws with considerable tenacity, at the same time withdrawing the head into the shell. They moved about on the ground with considerable agility, supporting their heavy bodies erect on their legs like a land-tortoise." Another species will occasionally snap, when owing to the friction of its serrated jaws against each other, a peculiar kind of barking sound is produced. Batagurs are eaten in Lower Bengal by some of the inferior castes of Hindus, and are kept for this purpose in tanks.

THE BIG-HEADED TORTOISE

Family *PLATYSTERNIDÆ.*


SIDE VIEW OF SKULL OF BIG-HEADED TORTOISE.
(From Boulenger).

This extraordinary creature (*Platysternum megacephalum*), which is an inhabitant of the south of China, Siam, and Burma, is the sole representative, not only of a very remarkable genus, but likewise of a distinct family, which appears to be to a great extent intermediate between that of the tortoises and that of the snappers. The most peculiar feature about this tortoise is the disproportionately large size of its head, in which the beak is much hooked; and an examination of the skeleton will show that the temporal fossæ of the skull differ from those of all the members of the preceding family in being roofed over with bone, as in the following family of the snappers. Moreover, the tail resembles that of the latter in its great length, and also in the circumstance that the articular surfaces of most of its vertebræ have the cup behind and the ball in front, whereas in the tortoise family just the reverse of this arrangement occurs. On the other hand, the carapace resembles that of the latter, and differs from that of the snappers in the absence of a rib-like process from its posterior angles passing backwards beneath the marginal bones. The



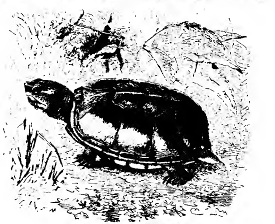
THE BIG-HEADED TORTOISE (½ nat. size).

carapace is characterised by its extreme depression and oval form; while the plastron is of moderate size, and connected with the carapace solely by ligament, so that bony buttresses are totally lacking. The head is covered with a continuous horny shield, and the hooked jaws are of great power. The toes are of moderate length, and but slightly webbed; all, save the fifth in the hind foot, being furnished with claws. The long and cylindrical tail becomes compressed at the end, and is covered with rings of quadrangular shields. In size this tortoise is small, the length of the carapace being only about 6 inches and that of the tail some three-quarters of an inch more. In the adult the colour is olive-brown above, and yellowish brown beneath, but the young is more brilliantly coloured. Of the habits and mode of life of this tortoise, nothing appears hitherto to have been ascertained.

THE MUD-TERRAPINS AND THEIR ALLIES

Families *CINOSTERNIDÆ* and *DERMATEMYDIDÆ*.

The mud-terrapins (*Cinosternum*) bring us to the first of two nearly related families confined to the New World, all of which differ from those previously noticed by the circumstance that the nuchal bone of the carapace gives off from each of its hinder angles a long rib-process which underlies the marginal bones. From the second family the mud-terrapins, of which there are eleven species inhabiting America north of the Equator, are broadly distinguished (as indeed they are from all other members of the order) by the fact that there are but eight bones in the plastron, owing to the absence of the unpaired entoplastral bone. As regards their other characters, the mud-tortoises resemble the *Testudinidæ* in the conformation of the vertebræ of the tail and in the absence of a roof to the temporal fossa of the skull, as well as in the extreme shortness of the tail. The carapace is more or less depressed, and is articulated by a bony suture with the plastron; the latter having the gular shields fused into one or wanting and its fore and hind-lobes more or less movable. The toes are fully webbed, and with the exception of the fifth in the hind-foot, strongly clawed. The best known representative of the genus is the Pennsylvanian mud-terrapin (*C. pennsylvanicum*), which attains a length of about 4½ inches, and inhabits eastern North America from New York to the Gulf of Mexico. In colour, the shell is brown or brownish above, and either yellow or brown beneath, the lines of junction between all the shields being dark



PENNSYLVANIAN MUD-TERRAPIN (½ nat. size).

brown or blackish, while the head and neck are brown with yellowish spots. From other species of the genus it is distinguished by the large size of the plastron, in which the anterior lobe is narrower than the mouth of the shell.

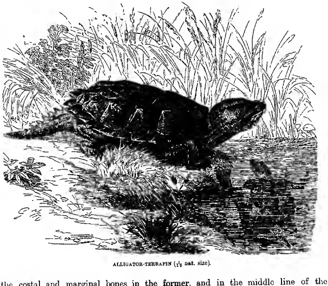
In general habits the mud-terrapins seem to be very similar to the fresh-water members of the tortoise family, although they prefer swamps and marshes to running waters. Carnivorous in their diet, they subsist chiefly on small fishes, insects, and worms, while they have been observed to capture newts. They will readily take a baited hook, and when thus caught sink rapidly and heavily to the bottom, thus causing the angler to believe that he has hooked a weighty fish. At the commencement of winter they bury themselves in moss, where they remain dormant till the following May. An extinct genus nearly allied to the mud-tortoises occurs in the Tertiary rocks of Baden.

Maw's Terrapin. Maw's terrapin (*Dermatemys mawi*) may be taken as a good representative of the second family, all the three genera of which are restricted to Central America. This family connects the preceding one with the snappers, agreeing with the latter in the presence of an entoplastral bone, and with the former in the characters of the vertebræ of the short tail, which have the cup in front, and the absence of a roof to the temporal fossa of the skull. Maw's terrapin and its allies further agree with the mud-terrapins in the incompleteness of the series of neural bones of the carapace; the hinder ones being wanting, and thus allowing the costal plates to meet in the middle line. Externally, the members of the present family may be distinguished from the *Testudinidæ* by the presence of an additional series of infra-marginal shields between the marginals and those of the plastron—a feature which they possess in common with the big-headed tortoise and the snappers. Maw's terrapin, which attains a length of some 15 inches, and is the sole representative of its genus, has the plastron large, and connected with the carapace by an elongated bridge; the gular shield being single, and the usual five other pairs of shields being present on the plastron. Unlike most other tortoises, there are twelve pairs of marginal shields, in place of the usual eleven. In the other two genera of the family—*Staurotypus* and *Claudius*—the plastron is reduced to a cross-like shape, and has but a short connection with the carapace; while the number of paired shields on the former is only four or or three, and the chin is provided with a pair of wattle-like appendages, of which there is no trace in Maw's terrapin. While in the two species of *Staurotypus* the plastron is connected with the carapace by a bony bridge, in the single representative of *Claudius* the junction is entirely ligamentous. This family is represented by several extinct genera in the Tertiary and Cretaceous strata of North America, one of which (*Baptemys*) had the full series of neural bones; and there appear to have been allied forms in the European Tertiaries.

THE SNAPPERS AND ALLIGATOR-TERRAPINS.

Family *CHELYDRIDÆ.*

Resembling the big-headed tortoise in the great relative size of their hook-beaked heads, and their elongated scaly tails, the snappers and alligator-terrapins of North and Central America constitute a well-marked family by themselves. In the first place, they differ from the species named in that the majority of the vertebræ of the tail have the articular cup behind, and the ball in front; while the temporal region of the skull is but partially covered with a bony roof. The American forms are further characterised by the relatively small size of the carapace, of which the hinder border is strongly serrated; while the cruciform plastron is likewise small, and but loosely articulated with the upper shell by a very narrow bridge. Moreover, both the upper and lower shells are not completely ossified till very late in life, vacuities remaining for a long time between



ALLIGATOR-TERRAPIN ($\frac{1}{12}$ nat. size).

the costal and marginal bones in the former, and in the middle line of the latter. Then, again, the plastron is peculiar in that the abdominal shields, which are separated from the marginals by an inframarginal series, do not meet one another in the middle line, although they may be connected by some small, irregular, unpaired, additional shields. Further, the enormous head cannot be completely retracted within the carapace, of which the anterior margin is deeply excavated in order to afford it room; and the chin is provided with one or more pairs of pendent wattles. With the exception of the fifth in the hind-limb, the toes are furnished with claws; and the long tail is crested above.

Alligator-Terrapin. The alligator-terrapin, or snapping turtle (*Chelydra serpentina*) is a giant among river-tortoises, and takes its name from a fancied resemblance to an alligator surmounted by a chelonian shell. It is one of two species belonging to a genus characterised by the eyes being directed upwards and outwards, so that their sockets are visible in a top view of the skull; by the tail being furnished with large horny shields on its lower surface; as well as by the absence of the supramarginal shields found on the carapace of Temminck's snapper. The carapace, which may attain a length of at least 20 inches, is characterised by its rugose surface, bearing three well-marked tuberculated keels, which tend to become smoother with advancing age; while its vertebral shields are remarkable for their great width. The snout is short and pointed, with a very narrow space between the eyes; the skin is warty, and on the chin is developed into a pair of wattles or barbels. In the young the tail is as long or even longer than the shell, becoming relatively shorter in the adult; its upper surface having a crest of large compressed tubercles, while the shields on the lower surface have been already alluded to. As in the other members of the family, the colour is a uniform olive-brown. The alligator-terrapin inhabits the rivers of North America to the eastward of the Rocky Mountains, from Canada to Mexico, and is also found in Ecuador. A second living species (*C. rossignonii*), distinguished, among other features, by the presence of four wattles on the chin, is met with in Guatemala and Mexico. Nearly allied to this is a third and extinct species (*C. murchisoni*) from the Miocene rocks of Baden; and as we have already seen that the mud-terrapins and probably also Maw's terrapin, were represented in the Tertiary strata of Europe, it is not improbable that the Eastern Hemisphere may have been the original home of the present group of families.

Temminck's Snapper

Attaining considerably larger dimensions than the alligator-terrapin, Temminck's snapper (*Macroclemmys temmincki*) is distinguished as a genus by the lateral position of the eyes, the sockets of which are invisible in a front view of the skull as well as by the presence of three or four additional or supramarginal shields on the sides of the carapace, and by the under surface of the tail being covered with small scales. The triangular head is proportionately even larger than in the alligator-terrapin, and the carapace has three very strongly marked longitudinal ridges. In length, the shell may measure at least a couple of feet, the tail being somewhat shorter. This species inhabits North America from Western Texas to Florida, extending northwards to Missouri.

Habits.

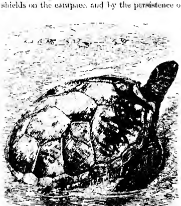
Since the alligator terrapin and Temminck's snapper appear to be very similar in their mode of life, their habits may be treated of collectively. Both these tortoises frequent alike the rivers and larger swamps of the United States, occurring in certain localities in enormous numbers, and most commonly in waters that have a muddy bottom, not even disdaining the most malodorous pools. As a rule, they lie in deep water, near the middle of the river or swamp, although at times they show themselves on the surface, where, with outstretched neck, they will float with the current. In populated districts the least sound is, however, sufficient to send them at once to the bottom, although in more remote regions they are less shy. At times they may be observed at considerable distances from the water, probably in search of food or of suitable spots to deposit their eggs. Temminck's snapper well deserves its name, since, from the moment of its escape from the egg, it commences to snap and bite at everything within its reach; and an adult has been known to make a clean perforation with its powerful beak through the blade of an oar half an inch in thickness. When one of these tortoises is taken into a boat, Weinland states that it will rear itself up on its hind-legs, and with lightning-like speed throw itself half a yard forwards to bite an oar; and they have been known to inflict terrible wounds on persons who have incautiously entered waters where they abound. In the water the movements of these reptiles are more rapid than those of most of their kin, and when in pursuit of prey they swim with surprising speed. Their food consists largely of fish, frogs, and other water-animals, while they will also frequently seize and drag down large aquatic birds, more especially ducks and geese. Tame specimens, that were kept in a pond in the United States, proved terrible foes to the stock of fish contained in the same. The eggs, which vary from twenty to thirty in number, and are about the size of those of a pigeon, are deposited on the ground near the water, and are carefully covered over with leaves. In captivity these tortoises thrive well in Europe, if the water be kept at a sufficiently high temperature; and a specimen of Temminck's snapper, which has lived for more than thirteen years in the Brighton Aquarium, grew to a length of between 4 and 5 feet from beak to tail, whereas, on its arrival, it measured less than a foot. In the confined limits of a tank the movements of this reptile were deliberate and sluggish, and gave no idea of the activity characterising the wild state. Although the flesh of the adult of this species has such a strong musky flavour as to be uneatable, that of the young is stated to be tender and palatable. The eggs are also sought after as articles of food; and when two or three females have laid together, as many as from sixty to seventy may be taken from a single nest.

The Turtles.

Family *Chelonidæ*.

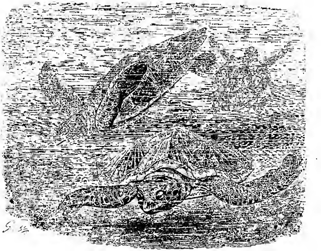
The families mentioned up to now have their feet more or less fully adapted for walking on land, and the majority of the toes furnished with well-developed claws or nails; while the carapace is generally of a somewhat oval form. The true turtles, on the other hand, while agreeing with the foregoing in having their shells covered with horny plates, are at once distinguished by the limbs being converted into flattened paddles, in which, at the most, only two of the toes are furnished with claws. They are further characterised by the heart-like form of the carapace, within which the head can be only partially withdrawn; while the plastron is never united by bone to the carapace, and vacuities remain in the latter between the costal and marginal bones either throughout life, or for a very long period. The skull has its temporal fossæ completely roofed over by bone; and the vertebræ of the very short tail have the articular cup in front and the ball behind. Entirely marine in their habits, and resorting to the shore only for the purpose of breeding, turtles differ from tortoises and terrapins in that the shells of their eggs are soft. In their entire conformation they are admirably adapted for an aquatic life, the body being depressed to facilitate rapid progress through the water, both the skull and shell being of unusually light and porous structure; while the limbs form most perfect paddles, capable of propelling the animals with great speed. The head is placed upon the neck in such a manner as to allow of the nostrils being readily raised above the surface of the water for the purpose of breathing, and the nostrils themselves can be hermetically closed by means of a fleshy valve. The three best known species of turtles, which are assigned to two genera, are inhabitants of all tropical and subtropical seas; one species—the loggerhead—occurring in the Mediterranean, and occasionally wandering northwards.

Green Turtle. Widely celebrated as being the source of the far-famed turtle-soup of civic banquets, the green turtle (*Chelone mydas*) is one of two species belonging to a genus characterised by the presence of four pairs of costal shields on the carapace, and by the persistence of the vacuities between the costal and marginal bones of the latter throughout life. The plastron is moreover distinguished by the presence of an intergular shield between the two gulars; while, as in the second genus, there is a row of inframarginal shields between the marginals and the proper shields of the plastron. The skull is of moderate size in comparison to the shell, with the sockets of the eyes placed nearly vertically, and separated by a broad bar of bone. Such are the characters common to the two species of the typical genus of the family. The green turtle is specially distinguished by its short beak, which is devoid of a hook at the tip, and by the shields of the carapace being in contact by their edges all through life. In the young, the carapace shows a faint median keel; while its hinder margin is at most but feebly serrated at all ages. Generally there is but a single claw on each paddle, although, in some instances, young specimens also have a claw on the second digit. In colour, the shell of the adult is olive or brown, with yellowish spots or marblings; while in the young it is uniform dark brown or olive above and yellow beneath, the limbs being bordered with yellow on the upper surface, and inferiorly yellow with a brown spot near the extremity. The food of the species consists of seaweeds, especially the seawrack, upon which the turtles graze at the bottom of the water, rising occasionally to the surface to breathe.



GREEN TURTLE.

Hawksbill Turtle. Generally rejected as food, the hawksbill turtle (*C. imbricata*) enjoys thereby no respite from persecution, since it is eagerly hunted for the beautifully mottled horny shields of its shell, which are the sole source of the tortoise-shell of commerce. In its young state, the hawksbill may be readily distinguished from the preceding species by the circumstance that the horny shields on the back of the three-ridged shell overlap one another like the tiles on a roof. With advancing age the shields gradually, however, become smooth, and in very old specimens they meet at their edges, as in other members of the order. At all ages the hinder margin of the carapace is more or less strongly serrated; and the compressed and sharply hooked beak will always serve to distinguish at a glance a hawksbill from a green turtle. Moreover, the limbs always have two claws. In the adult the shields of the carapace are beautifully marbled and mottled with yellow and dark reddish brown, while the plastron is yellow, and the shields on the head and paddles are brown with yellow margins. In size this species is somewhat inferior to the green turtle, the carapace attaining a length of about 32 inches against 42 inches in the latter. In habits the hawksbill differs markedly from the green turtle, being exclusively carnivorous.

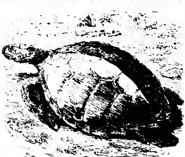


HAWKSBILL TURTLES SWIMMING ([illegible] nat. size)

Loggerhead Turtle. The third, and probably the largest species of turtle, is the loggerhead (*Thalassochelys caretta*), easily recognised by its enormous head and the presence of at least five costal shields on each side of the carapace, which differs from that of the two preceding species by becoming completely ossified in the adult state. The beak is strongly hooked; and while in the young there are usually two claws to each paddle, one of these frequently disappears in the adult. In colour, the adult is brown above and yellowish beneath, but the young is uniformly dark brown or blackish. The Mexican loggerhead (*T. kempi*), from the Gulf of Mexico, differs in having a median ridge on the bone of each jaw, whereas in the ordinary species such ridges are confined to the investing horny sheath. According to Mr Gosse, loggerheads feed on cuttles and other molluscs, their powerful beaks enabling them to crush strong conch-shells as easily as a man can crack a nut.

Habits

Apart from the difference in their food all turtles appear to be similar in their general mode of life, never leaving the sea except for the purpose of laying their eggs and then shuffling along in an awkward, ungainly manner. During the laying season they resort to low sandy coasts, especially infrequented tropical islands, in vast numbers; and if once turned on their backs while on shore, are unable to right themselves again. This habit of resorting to the land to lay their eggs clearly proves, it may be observed, the descent of turtles from fresh-water members of the order. Writing of the green turtles at Aldabra, one of the Seychelles group of islands, Mr Spurs remarks that the males permanently frequent the bay of that island, the females when they attain full maturity (twenty or twenty-five years) disappearing altogether. When the latter come to the shore for the purpose of laying, their shells are covered with barnacles of two or three weeks' growth. Commercially, the females are more valuable than the males, and, as they are more easily captured, the proportion found on the island is one female to every ten males, although, for one of the latter, about ten of the former sex are hatched. Turtles generally come ashore on fine moonlight nights, displaying great caution in landing, and then generally uttering a loud hissing noise which serves to disperse many of their enemies. Once landed, the female turtle, writes Audubon, "proceeds to form a hole in the sand, which she effects by removing it from under her body with her hind-flippers, scooping it out with so much dexterity that the sides seldom, if ever, fall in. The sand is raised alternately with each flipper, as with a large ladle, until it has accumulated behind her, when, supporting herself with her head and forepart on the ground fronting her body, she, with a spring from each flipper, sends the sand around, scattering it to the distance of several feet. In this manner the hole is dug to the depth of eighteen inches, or sometimes more than two feet. This labour I have seen performed in the short space of nine minutes. The eggs are then



YOUNG LOGGERHEAD TURTLE

dropped one by one, and disposed in regular layers, to the number of one hundred and fifty, or sometimes nearly two hundred. The whole time spent in this part of the operation may be about twenty minutes. She now scrapes the loose sand back over the eggs, and so levels and smooths the surface that few persons on seeing the spot could imagine that anything had been done to it. This accomplished to her mind, she retreats to the water with all possible despatch, leaving the hatching of the eggs to the heat of the sand." During a season each female will lay three clutches of eggs, at intervals of from a fortnight to three weeks, usually from one hundred and twenty-five to one hundred and fifty in number. No sooner are the young turtles hatched, than hosts fall victims to land-crabs, frigate-, and other sea-birds, while, when they reach the sea, they are attacked by swarms of predaceous fishes. To escape the latter, the young reptiles allow themselves to be carried out by currents into deep water, where they are less readily seized. During the breeding-season the males fight desperately with one another, to the great joy of the sharks, by whom the disabled ones are seized.

When first laid, the round eggs of turtles are never quite full, but before hatching become fully distended. In describing the breeding-habits of the turtles kept in a pond near the dockyard in Ascension Island, Moseley states that in the breeding-season the females dig great holes as large as themselves in a bank of sand, in which to deposit their eggs. The sand in which the eggs are laid does not feel warm to the hand, but during the daytime is rather cool, while it is at all times moist. Its temperature appears to undergo no material variation, owing to the depth at which the eggs are deposited; such medium amount of heat being sufficient for the hatching.

Although a large number of green turtle are captured by being turned on their backs while on shore, in the Seychelles and Bahamas they are harpooned. In Keeling Island the method of capture is described by Darwin as follows:— "The water is so clear and shallow that, although at first a turtle dives quickly out of sight, yet, in a canoe or boat under sail, the pursuers, after no long chase, come up to it. A man, standing nearly in the bows at this moment dashes through the water upon the turtle's back, then, clinging with both hands to the shell of the neck, he is carried away, till the animal becomes exhausted, and is secured." In China and Mozambique turtles are captured by means of sucking-fishes, which are taken to a spot where the reptiles are basking upon the surface of the water. Each fish has a ring round its body to which a line is attached, and as soon as it securely fastens itself by its sucking-disc to the back of a turtle, both captor and captured are drawn ashore. Although those of the loggerhead have a somewhat musky taste, the eggs of the other species of turtle are much esteemed as articles of food, while all yield a valuable oil.

Tortoise Shell. As already said, tortoise-shell is a product of the hawksbill turtle, and it is too often taken from the back of the living animal by the aid of heat, after which painful operation the unfortunate turtle is returned to its native element. As the raw tortoise-shell is very unlike the finished article, with which all are familiar, Bell's brief account of the process of manufacture may be quoted. The horny shields, as removed from the turtle, being highly curved, "the uneven curvature is first of all to be removed, and the plate rendered perfectly flat.

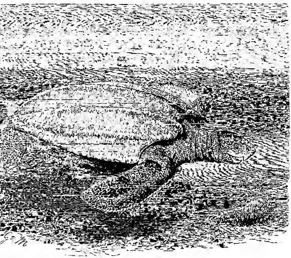
This is effected by immersing it in hot water, and then allowing it to cool under heavy pressure between smooth blocks of wood, or metallic plates. The surface is then rendered smooth, and the thickness equal, by scraping and filing away the rough and prominent parts. In this way each plate receives an equal and smooth surface. But it is in many cases desirable to employ larger pieces than can be obtained from single plates, and two pieces are then united together in the following manner. The edges are bevelled off to the space of two or three lines, and the margins, when placed together, overlap each other to that extent. They are then pressed together by a metallic press, and the whole is submitted to the action of boiling water, and by this means the two pieces are so admirably soldered together as to leave no indication of the line of union. By the application of heat, also, the tortoise-shell may be made to receive any impression by being pressed between metallic moulds." Necklaces, etc., are made by pressing the fragments and dust in moulds.

Extinct Turtles. Turtles, more or less closely allied to the existing kinds, abound in marine strata of the Tertiary and Cretaceous epochs, some belonging to extinct and others to the living genera. Among the latter, the gigantic Hoffmann's turtle (*Chelone hoffmanni*), from the chalk of Holland, appears to have been allied to the hawksbill, but had a shell of some 5 feet in length. Extinct loggerheads occur in the London Clay; and an allied extinct genus (*Lytoloma*), common to the same formation and the upper Cretaceous deposits, was remarkable for the great length of the bony union between the two branches of the lower jaw, and also for the circumstance that the aperture of the internal nostrils was placed right at the hinder extremity of the palate, as in crocodiles. In strata older than the Chalk, such as the Purbeck and other Oolitic rocks, we meet with turtles having heart-shaped shells, but clawed limbs, and a vacuity in the centre of the plastron, these forming an extinct family (*Acichelyidæ*), from which the modern turtles have probably originated.

Leathery Turtles.

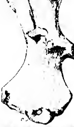
Family *DERMOCHELYIDÆ.*

The remarkable leathery turtle, or luth (*Dermochelys coriacea*), which is the solitary survivor of a series of extinct forms, is one of those animals whose serial position is a matter of dispute among naturalists; some of whom regard it as so different from all other Chelonians, that it ought to represent a suborder by itself, while others believe it to be merely a highly specialised form allied to the true turtles. From the evidence afforded by extinct species, the latter view, to our thinking, appears the more likely to be the true one. The essential peculiarity of the leathery turtle is to be found in the nature of its carapace, which is a mosaic-like structure composed of a number of irregular discs of bone closely joined together, and entirely free from the backbone and ribs. In certain extinct forms the carapace, on the other hand, is represented merely by a row of marginal bones; from which it is inferred that these reptiles have been derived from true turtles by a gradual disintegration and breaking up of the carapace. In the living genus the carapace is completely bony, and marked by seven prominent longitudinal keels; but the plastron is much less fully ossified, and carries five similar keels, the unpaired entoplastral bone being wanting. The head, which is covered with small shields, is remarkable for its relatively large size and globose form; the beak having two triangular cusps situated between three deep notches. The jaws differ from those of the true turtles in being sharp-edged from end to end, without any expanded bony palate; and there is also an important difference in the structure of the skull itself, which may, however, be apparently the result of specialisation. As in the true turtles, the limbs are converted into flattened paddles, which are, however completely destitute of claws; the front pair being much elongated, narrow, and pointed, while the hinder ones are short and truncated. The humerus, or bone of the upper arm, has the same general form as in the true turtles; and is thus very unlike the corresponding bone of other members of the order. The process marked *b* in the figure on p. 88 is more developed than in the turtles; and the foramen *e* at the lower end is unique in the order. Largest of living turtles, the leathery turtle exceeds 6 feet in length; and while in the young the front flippers are equal in length to the shell in the adult they become shorter. The general colour is dark brown, which may be either uniform, or relieved with yellow spots; the longitudinal tuberculated keels on the shell, as well as the margins of the limbs, being invariably yellow in the young.



LEATHERY TURTLE ([illegible] nat. size).

This turtle is generally distributed throughout the tropical portions of the Atlantic, Indian, and Pacific Oceans, from whence it occasionally wanders to the coasts of cooler regions. Yearly becoming scarcer, it is, however, one of those species which stand a fair chance of extermination at no very distant date. Although but little is known as to the mode of life of this turtle, it appears that its food is chiefly of an animal nature, comprising fish, crustaceans, and molluscs. In the breeding-season it appears in numbers on the Tortugas Islands, off the coast of Florida, and sometimes in still greater abundance on the sandy shores of Brazil. Arriving somewhat later than the true turtles, it deposits its eggs in a similar manner, laying as many as three hundred and fifty in two batches; while at times, when three or more females have a nest in common, upwards of a thousand eggs may be found in a single spot. When hatched, the young turtles immediately seek the water, where, however, they have almost as many foes as on land; so that it is probable only a very small percentage arrive at maturity. The strength and weight of a full-grown individual are very great; one captured some years ago on the coast of Tenasserim, requiring the combined efforts of ten or twelve men to drag it on to the beach. The flesh has an unpleasant flavour, and is not, therefore, generally eaten.



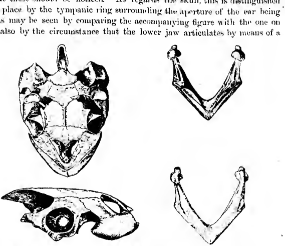
FRONT VIEW OF LEFT HUMERUS OF AN EXTINCT LEATHERY TURTLE.

Gigantic as is the existing leathery turtle, it was considerably exceeded by some of its extinct allies. Among these, the huge *Eosphargis*, from the London Clay, with a skull of nearly a foot in length, apparently had a carapace consisting only of one median row of broad-keeled bony plates, and a border of marginal bones; while in *Psephophorus*, from the higher Eocene and Miocene strata of the Continent, both upper and lower shells were formed of mosaic-like bones, which, it is thought, were overlain by horny shields. In the earlier *Protostega* and *Protosphargis*, from the Cretaceous rocks of North America and Europe, the upper shell appears to have been represented merely by a row of marginal bones, while the lower one was very stoutly ossified; some of these early forms probably attained a length of from 10 to 12 feet.

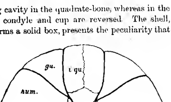
THE SIDE-NECKED TORTOISES.

Families *CHELYIDÆ* and *PELOMEDUSIDÆ*.

In place of withdrawing the head into the shell by means of an S-like flexure of the neck in a vertical plane, as in all the groups hitherto described, the remainder of the living tortoises with complete shells bend the neck sideways in a horizontal plane (as shown in the illustration on p. 92), and thus bring the head within the margins of the shell. Accordingly, the group is collectively spoken of as the side-necked tortoises, or Pleurodira. This character is alone amply sufficient to separate the group from the foregoing assemblage of S-necked or Cryptodiran tortoises, but since there are also certain features by which the skulls and shells of the two groups can be identified, it is important that these should be noticed. As regards the skull, this is distinguished in the first place by the tympanic ring surrounding the aperture of the ear being complete, as may be seen by comparing the accompanying figure with the one on p. 47, and also by the circumstance that the lower jaw articulates by means of a knob-like condyle with a corresponding cavity in the quadrate-bone, whereas in the preceding group the positions of the condyle and cup are reversed. The shell, which is always fully developed and forms a solid box, presents the peculiarity that both the carapace and the hinder part of the plastron are immovably welded to the bones of the pelvis; its upper and lower moieties thus having a bond of union which is totally lacking among the S-necked tortoises. Further, the vertebræ of the neck are furnished with projecting lateral or transverse processes, which are absent from the latter group.



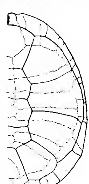
LOWER AND SIDE VIEWS OF SKULL AND UPPER AND LOWER ASPECTS OF LOWER JAW OF GREAVED TORTOISE. (From Gray, *Proc. Zool. Soc.*, 1870.)



FRONT PORTION OF THE PLASTRON OF A SIDE-NECKED TORTOISE, WITH THE HORNY SHIELDS REMOVED.

The thick lines indicate the boundaries of the shields.

In addition to these absolutely characteristic features, there are certain other points connected with the anatomy of the side-necked tortoises which demand a brief notice. With the exception of one species, which lacks horny shields on the shell, the whole of these tortoises are characterised by the presence of an intergular (*igu*) shield between the two gulars (*gu*) on the front of the plastron; such intergular shield being, as we have seen, but very rarely present in the S-necked group. Very generally among the present assemblage one or more of the pairs of costal bones of the carapace may meet in the middle line, owing to the absence of some of the median unpaired series of bones; in certain cases the whole of the costals thus meeting, owing to the absence of all the neural bones. Whereas, in one family of the group the plastron contains the same nine bones as in the side-necked tortoises, in a second family there are eleven bony elements in this part of the shell, owing to the presence of an additional (mesoplastral) pair between the normal hyo- and hypo-plastral bones.

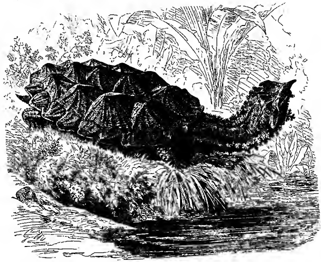


RIGHT HALF OF THE CARAPACE OF THE BLACK STERNOTHERE, WITH THE HORNY SHIELDS REMOVED.

The side-necked tortoises, of which the great majority may be included in the two families mentioned above, are all of fresh-water habits, and at the present day are exclusively restricted to the Southern Hemisphere, while they are the only members of the order found in Australia and New Guinea. During the earlier portion of the Tertiary period they extended, however, into the Northern Hemisphere, and in the preceding Secondary period were abundantly represented in Europe. These facts show that the group is a very ancient one; and by the presence of the additional mesoplastral elements in the lower half of the shell of some of its representatives it is allied to a third and totally extinct group, which disappeared before the close of the Secondary period.

Matamata Tortoise. The extraordinary reptile depicted in the accompanying illustration, and known as the matamata (*Chelys fimbriata*) is the typical representative of the first of the existing families of the group—*Chelydæ*. The various genera included therein are collectively characterised by having the normal nine bones in the plastron, by the neck being incapable of complete retraction within the margins of the shell, and the absence of a bony temporal arch to the skull. Eight genera are included in the family, the range of which is restricted to South America, Australia, and New Guinea.

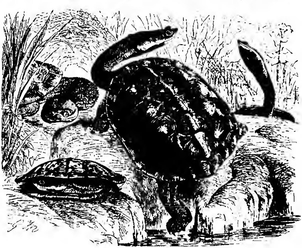
The matamata, which is an American species inhabiting Guiana and Northern Brazil, and is the sole representative of its genus, is easily recognised by its broad and elongated neck, of which the sides are fringed with peculiar fimbriated projections, and the depressed and triangular head terminating in a proboscis-like nose, and furnished with very small eyes. Not less characteristic is the equally depressed and much corrugated shell, in which the carapace bears three longitudinal ridges, subdivided into nodose protuberances by cross-valleys; the horny shields of the same being extremely rugose, and marked with deep radiating striæ. The vertebral shields are broader than long, and the hinder marginals are more or less strongly serrated, while there is a distinct nuchal shield on the front edge of the carapace. On the removal of the horny shields from the carapace, it is seen that only the last pair of costal bones meet in the middle line, owing to the presence of but seven neural bones. The plastron is narrow and deeply notched behind, the tail is very short, and the toes are fully webbed. In addition to the rows of fimbriated appendages on each side of the neck, there is a similar outgrowth of skin on the chin and larger pair of appendages above the ears. In colour the adult is uniform brown, but the young are prettily marked with bands of brown and yellow on the chin and neck, while the shell is ornamented with black and yellow spots. The species is of comparatively large size, the shell attaining a length of 15 inches.



MATAMATA TORTOISE (¼ nat. size).

Unfortunately, but little is known as to the mode of life of this strange tortoise. When in its native element, the warty appendages on the neck float in the water like some vegetable growth, while the rugged and bossed shell strongly resembles a stone: and it is thus probable that the whole appearance of the creature is advantageous either in deluding its enemies or in attracting to it the animals on which it feeds—the latter being the more likely hypothesis. Although it appears that the matamata will occasionally eat vegetable substances, its chief food consists of fish, frogs, and tadpoles, some of which may probably be attracted within reach by mistaking the appendages on the neck for plants or animals on which they feed. The matamata is, however, stated to capture some of its prey by swimming swiftly among water-plants, diving immediately that a fish or frog is seized in its beak. In captivity this tortoise is sluggish, frequently dying after a few weeks through refusal to feed.

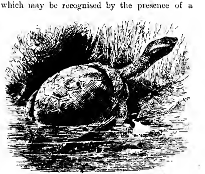
Snake Necked Tortoises. The snake-necked tortoises, of which there are two South American species (*Hydromedusa maximiliani* and *tectifera*), agree with the matamata in their long necks and weak jaws, but differ in their smooth shell, the absence of a proboscis to the nose, and the presence of only four claws on each foot—the matamata having five claws on the fore-feet and four on the hinder pair. The flattened shell in the young state has an interrupted median ridge, and presents the unique peculiarity that the broad nuchal shield of the carapace is placed behind the first pair of marginals (which consequently meet in the middle line) and thus simulates a sixth vertebral shield. The figured species (*H. tectifera*), which ranges from Southern Brazil to Buenos Aires, has a shell measuring about 8 inches in length, and its feet largely webbed. In colour, the carapace is dark brown and the plastron yellowish, with brown spots in the young; the head and neck being olive, with a curved white streak on each side of the throat, and a broader white band, edged with black, running along the sides of head and neck.



SNAKE-NECKED TORTOISE (½ nat. size).

Nocturnal and carnivorous in their habits, the snake-necked tortoises appear to agree in their general mode of life with the majority of fresh-water species. During the daytime they are generally to be found lying asleep on some dry spot near the water, with the neck bent on one side, and the head, like the limbs and tail, retracted within the margins of the carapace. When disturbed, the head and neck are, however, shot out with marvellous rapidity, reminding the observer of the sudden dart of a snake.

Australian Long-Necked Tortoises. In Australia and New Guinea the place of the preceding group is taken by another genus of long-necked tortoises, technically known as *Chelodina*, the members of which may be recognised by the presence of a normally placed nuchal shield on the carapace, coupled with the circumstance that the intergular shield of the plastron, instead of being placed between the gulars, as in the figure on p. 89, is situated behind the latter, which consequently meet in the middle line. The vertebral horny shields are longer than broad, and the whole of the shields remarkable for their extreme thinness. On removing the latter from the carapace, it will be found that, owing to the absence of neural bones all the pairs of costal bones meet in the middle line,—a peculiarity shared with one American, and two other Australian genera of the family. There are four species of these long-necked tortoises, three of which are found in Australia, while the fourth is Papuan.

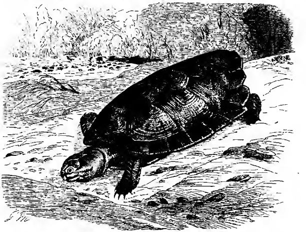


AN AMERICAN SIDE-NECKED TORTOISE (*Hydraspis*).

Other Genera. In addition to the foregoing, there are four other genera belonging to the family under consideration, collectively distinguished by their shorter necks, the length of which is inferior to that of the back. Of these the American *Rhinemys*, *Hydraspis*, and *Platemys* are characterised by the narrow anterior extremity of the lower jaw, and by the first vertebral shield of the carapace being wider than either of the others. The second of these genera, of which a member is represented in the accompanying figure, is by far the most numerous in species; and is noteworthy on account of being represented by a fossil species in the Eocene deposits of India. The third genus differs from the other two in the absence of neural bones to the carapace. On the other hand, the two Australian genera—*Emydura* and *Elseya*,—both of which present the feature last mentioned are distinguished by the broad anterior extremity of the lower jaw, and by the first vertebral shield of the carapace not exceeding the others in size.

Greaved Tortoises. The tortoises which may be conveniently designated by a translation of their scientific title (*Podocnemis*)—so named on account of the presence of a pair of large shields on the outer side of the hind-foot of the typical species—bring us to the second family of the group under consideration. This family (*Pelomedusidæ*), which contains three genera, and is now confined to Africa, Madagascar, and South America, is broadly distinguished from the last by having eleven elements in the plastron, owing to the presence of a pair of mesoplastral bones; while the neck is completely retractile within the margins of the shell. The skull differs from that of the preceding family in having a bony temporal arch, as shown in the figure on p. 89; while it lacks the distinct nasal bones generally found in the former.

The largest and best known representative of the whole family is the giant Amazonian tortoise (*Podocnemis expansa*), which considerably exceeds in size all



GIANT AMAZONIAN TORTOISE ($\frac{1}{6}$ nat. size).

other members of the entire group, having a shell which may measure as much as 30 inches in length. It belongs to a genus including seven existing species, of which six are South American, while the seventh is an inhabitant of Madagascar. This extremely anomalous distribution is to some extent explained by the occurrence of a fossil representative of the genus in the Eocene strata of India, which probably indicates that these tortoises were at one time widely spread. As a genus, these tortoises are characterised by the skull having a roof over its temporal region, coupled with the presence of five claws on the fore-feet, and four on the hinder pair, and likewise by the circumstance that the mesoplastral bones are small and confined to the edges of the plastron, so that they are widely separated from one another in the middle line. The toes are broadly webbed, and the tail is remarkable for its extreme shortness.

The figured species, which inhabits tropical South America to the eastwards of the Andes, and is extremely abundant in the upper part of the Amazonian system, has the shell expanded posteriorly, and much depressed in the adult, although at an earlier stage it has a roof-like form. The chin is furnished with two small wart-like appendages; and the hind-foot characterised by the presence of two very large shields on its outer side. In colour, the upper shell is brown or olive, with darker markings, while the plastron is yellowish, spotted with brown; the young being olive above and yellow beneath, with some yellow spots on the head. All the other members of the genus are of greatly inferior dimensions; a second Amazonian species (*P. sextuberculata*), having a shell of scarcely more than a foot in length, and being distinguished from its larger relative by the presence of only a single wattle on the chin.

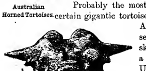
The best account of the habits of these tortoises is the one given by Humboldt, who speaks of the large species by its native name of arrau. On the Orinoco, according to this account, the period of egg-laying coincides with that of the lowest level of the waters of the river, or from the end of January till the latter part of March. During January the tortoises collect in troops, which soon leave the water to bask on the warm banks of sand exposed by the lowering of the river. Throughout February they may be found on such banks during the greater part of the day; but early in March the several troops collect in larger bodies, and then make their way to the comparatively few islands where the eggs are habitually deposited. At this time, shortly before the egg-laying commences, thousands of the tortoises may be seen arranged in long strings around the shores of the islands in question, stretching out their necks, and holding their necks above water, in order to see whether there is anything to prevent their landing in safety. As the creatures are exceedingly timid, and especially averse to the presence of human beings or boats, the Indians, to whom the harvest of tortoise eggs is of the utmost importance, take every precaution to prevent them being disturbed, posting sentinels at intervals along the banks, and warning all passing boats to keep in the middle of the river. When the tortoises have landed, the laying of the eggs takes place at night, and begins soon after sunset; the females digging holes of some three feet in diameter and two feet in depth, by the aid of their powerful hind-limbs. So great is the contention for space, that one tortoise will frequently make use of a pit dug by a neighbour, and in which one set of eggs has already been deposited, although not yet covered over with sand; two layers of eggs thus occupying one area. The crowding and jostling of the reptiles necessarily leads to an immense number of eggs being broken, which is estimated at a fifth of the whole; the contents of the fractured shells in many places cementing the loose sand into a coherent mass. The number of tortoises on the shore during the night being so large, many of them are unable to complete the work of egg-laying before dawn; and these belated individuals become quite insensible to danger, continuing there even in the presence of the Indians, who repair to the spot at an early hour.

The great assemblage of these Chelonians takes place on one particular island in the Orinoco, hence known as the Boca de la Tortuga; and according to native accounts, no other spot is to be met with on the river from its mouth to its junction with the Apure where eggs can be found in abundance. On the island in question, the number of eggs deposited is enormous; a large stretch of smooth sandy beach being underlain with an almost continuous layer. To determine the position and extent of the deposit, a long pole is thrust down at intervals into the sand; the sudden want of resistance to its descent proclaiming when the loose layer containing the eggs has been reached. According to measurements taken by Humboldt, the stratum extended to a distance of one hundred and twenty feet from the water, and averaged three feet in depth. The whole is regularly parcelled out among the Indians, who proceed to work the layer with the regularity of miners. The earth having been removed, the eggs are carried in small baskets to the neighbouring encampment, where they are thrown into long wooden troughs of water. Here they are broken and stirred up with shovels, and the mass then left in the sun till all the oily matter has collected at the surface, whence it is continually ladled off, and taken off to be boiled over a quick fire. The result of this process is a limpid, inodorous, and scarcely yellow substance, known as "turtle-butter," which can be used for much the same purposes as olive-oil. In spite of the enormous quantity of eggs thus taken, numbers are hatched, and Humboldt saw the whole bank of the Orinoco swarming with small tortoises of an inch in diameter, that escaped only with difficulty from the pursuit of the Indian children. All these tortoises are vegetable feeders; and the females greatly exceed the males in size. On the upper Amazon the large species, according to Bates, is captured either by means of nets or by shooting with arrows. On such occasions, after the net is set in a semicircular form at one extremity of a pool, the rest of the party spread themselves around the swamp at the opposite end, and begin to beat with poles in order to drive the tortoises towards the middle. This process on the occasion referred to "was continued for an hour or more, the beaters gradually drawing nearer to each other, and driving the hosts of animals before them; the number of little snouts constantly popping above the surface of the water showing that all was going on well. When they neared the net, the men moved more quickly, shouting and beating with great vigour. The ends of the net were then seized by several strong hands and dragged suddenly forwards, bringing them at the same time together, so as to enclose all the booty in a circle. Every man now leapt into the enclosure, the boats were brought up, and the turtles easily captured by the hand and tossed into them." Altogether, about eighty individuals were captured in the course of twenty minutes or so. In shooting tortoises, the arrow employed has a strong lancet-shaped steel point, fitted to a peg which enters the tip of the shaft. To the latter the peg is secured by a hank of twine some thirty or forty yards in length, and neatly wound round the body of the arrow. When a tortoise is struck, the peg drops out from the shaft, and is carried down by the diving animal, leaving the latter floating on the surface. Thereupon the sportsman paddles up to the arrow, and proceeds to "play" his victim until it can be drawn near to the surface, when it is struck with a second arrow, after which, by the aid of the two cords, it can be safely drawn ashore. In many villages on the Amazon every house has a pond, in which a number of these tortoises are kept for food.

Allied Genera. The other two genera of the family—*Pelomedusa* and *Sternotherus*—differ from the first by the absence of a bony roof to the temporal region of the skull, and likewise by the presence of five claws in both the front and hind-feet. Whereas, however, the former has the mesoplastral elements of the plastron small and similar to those of the greaved tortoises, in the latter they are as well developed as the other elements of the plastron, meeting in the middle line. *Pelomedusa* is represented by a single species common to Africa and Madagascar, but of the six species of *Sternotherus*, five are exclusively African, while the sixth inhabits both Eastern Africa and Madagascar. The right half of the upper shell of one of the species is represented on p. 90.

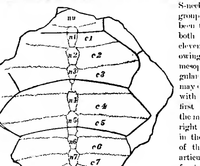
Fly River Turtle. A remarkable Chelonian (*Carettochelys insculpta*) from the Fly River, New Guinea, differs from all other members of the group, in the absence of horny shields on the shell and the conversion of the limbs into paddles, each of which carries but two claws. The neck is not retractile. In the carapace there are six very small neural bones, which are not in contact with one another, thus allowing each pair of costals to meet in the middle line, and the plastron has only the usual nine bones. A wavy sculpture ornaments the whole of the external surface of the shell, which attains a length of about 18 inches. The head is large, and the tail relatively short. The species, which represents a separate family (*Carettochelyidæ*), is still very imperfectly known; and it has been suggested that it does not belong to this group at all. It is not improbable that a chelonian (*Hemichelys*), from the Eocene rocks of India, indicates a second member of the same family, as its shell was similarly devoid of horny shields.

Australian Horned Tortoises. Probably the most aberrant members of the whole order were certain gigantic tortoises (*Miolania*) from the superficial deposits of Australia, characterised by the presence of several pairs of horn-like protuberances on the skull, and also by the investment of the tail in a bony sheath, recalling that of the armadillos. Unfortunately, the shell of these strange reptiles is known only by fragments; but, from the conformation of the bones of the feet, we are enabled to say that they were terrestrial, while the structure of the palate indicates that they were herbivorous. They clearly constitute a fourth family (*Miolaniidæ*) of side-necked tortoises.


FRONT VIEW OF SKULL OF HORNED TORTOISE.

Extinct European Genera. The Secondary rocks of Europe contain the remains of a number of extinct tortoises which may be referred to a fifth family (*Plesiochelyidæ*) of the group. While agreeing with the existing *Chelyidæ* in having but nine bones in the plastron, these extinct forms differ by the much greater thickness of their shells, and also by the circumstance that only one of the lower bones of the pelvis is welded to the upper surface of the plastron, whereas in the existing families both are thus united. Abundant in both the Oolitic and Wealden rocks, the majority of these tortoises are referred to the genus *Plesiochelys*, although some, as the one of which the carapace is represented in the figure on the next page, are separated as *Hylæochelys*, being distinguished by the enormous width of the vertebral shields, in which the breadth may be three times the length. Nothing approaching this conformation is to be met with among living representatives of the order.

Generalised Chelonians. Certain extinct tortoises, such as *Pleurosternum* from the Purbeck Oolite of Swanage, and *Baena* of the Eocene rocks of the United States, indicate the existence of an extremely generalised group of the order *Amphichelydia*, presenting many characters common to the existing S-necked and Side-necked groups, and which may have been the ancestral stock of both the latter. All have eleven bones in the plastron, owing to the presence of mesoplastrals and an intergular shield but the pelvis may or may not be connected with the plastron. In the first of the genera named, the mesoplastral bones extend right across the shell to meet in the middle line, and one of the bones of the pelvis articulates to a smooth oval facet on the plastron. On the other hand, in the second genus, the mesoplastral bones are incomplete, as in the existing greaved tortoises, and there is no union between the pelvis and the plastron. Since it is probable that the plastron of the Chelonians has originated from a system of abdominal ribs similar to those of the tuataras (Chapter VI.), it is interesting to notice that these generalised tortoises had a larger number of plastral elements than are to be found in the majority of the existing representatives of the order.



IMPERFECT CARAPACE OF WIDE-SHIELDED WEALDEN TORTOISE.

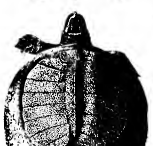
THE SOFT-TORTOISES.

Family *TRIONYCHIDÆ*.

The last group of the order comprises the soft river-tortoises, now confined to the warmer regions of Asia, Africa, and North America, but which, during the middle portion of the Tertiary period, appear to have been extremely abundant in the rivers of England and other parts of Europe. The whole of these tortoises are included in a single family which forms a group of equivalent value to the S-necked and Side-necked sections; and it is not a little remarkable that while in the greater part of their organisation they approximate to the former group, in certain features connected with the skull they come nearer to the latter. The most striking peculiarity of the soft-tortoises is to be found in the nature of their shells,

which are covered with a raised sculpture of variable form, and are quite devoid of horny shields. The lower shell, or plastron, is always very imperfectly ossified, and completely separate from the carapace, while the carapace never has a complete series of marginal bones, and passes at its borders into a soft expansion of skin, from which the name of the group is derived. If marginal bones occur at all, they are confined to the hinder border of the shell, and are unconnected with the ribs; having, in fact, nothing in common with the bones so named in other tortoises, and being doubtless of independent origin. In being unconnected with the plastron, the pelvis resembles that of the S-necked group, and the head is retracted by a similar S-like flexure of the neck in a vertical plane. In regard to the mode of articulation of the lower jaw with the skull, and likewise in the presence of a notch in the hinder border of its tympanic ring, the soft-tortoises again resemble the group last mentioned; although in the general form of the skull and the conformation of the palate they come nearer to the Side-necked group. A distinctive peculiarity of the skeleton is to be found in the presence of at least four joints in the fourth toe of each foot. Externally, the soft-tortoises are characterised by their long necks, which, together with the head, can be completely withdrawn into the shell, and also by the proboscis-like snout, and the thick fleshy lips concealing the jaws. The ear is completely concealed; and each foot, as indicated by the scientific name of the group, has but three claws, which are borne by the three inner toes. As a rule, the colour of the skin is greenish olive, with yellow or orange spots, passing into streaks on the under surface of the head; while some species have a few much larger eye-like spots on the back of the shell.

Typical Genus. Although the whole of the soft-tortoises are included in a single family, they are arranged in six distinct genera, three of which are nearly allied to one another, as are likewise the remaining three among themselves. The first and largest genus, *Trionyx*, contains fifteen living species, with a distribution coextensive with that of the family. These are characterised by the absence of a fold of skin on the hinder part of the under shell, beneath which the leg may be concealed, by the sculpture on the shell being generally in the form of wavy raised lines, and by the hyo- and hypoplastral bones of the lower shell remaining distinct from one another. In the skull, as shown in the figure on p. 89, the sockets of the eyes are placed relatively far back, and widely separated from the aperture of the nose. Among the better-known species we may mention the Gangetic soft-tortoise (*T. gangeticus*), now confined to the river system from which it takes its name, but formerly found, as shown by fossil specimens, in the Narbada; the length of the shell and fleshy disc reaching as much as 2 feet. Like all the Old World representatives of the genus, this species has eight pairs of costal bones in the carapace; while it belongs to a subgroup characterised by having two neural bones between the first pair of costals, and by the absence of a pronounced ridge in the middle of the upper surface of the extremity of the lower jaw. The soft-tortoise of the Nile (*T. triunguis*), ranging over Africa and Syria, and attaining still larger dimensions, belongs to a second subgroup, distinguished by having only a single neural bone between the first costals; while Phayre's soft-tortoise (*T. phayrei*), of Burma, may be taken to represent a third section differing from the last by the presence of a median ridge in the front of the lower jaw. On the other hand, all the American soft-tortoises, of which *T. ferox* is a well-known example, differ by having only seven pairs of costal bones. Numerous representatives of the genus occur in the Miocene and Eocene strata of Europe, as well as in the Tertiary rocks of India and the United States. Two other members of the first subfamily, confined to Asia, represent as many genera. Of these Cantor's soft-tortoise (*Pelochelys cantori*), from India, Burma, and Malayana, has the sockets of the eyes placed more anteriorly than in the type genus. This forward position of the eye-sockets is still more marked in the much elongated skull of the great Indian chitra (*Chitra indica*), where they are placed close up to the nose.


CANTOR'S SOFT-TORTOISE.

Granulated Soft-Tortoises. The three remaining genera of the family are characterised by the sculpture of the shell generally taking the form of small pustules, and thus resembling shagreen; while the hyo- and hypoplastral bones of the lower shell are united; and there is a flap of skin on each side of the inner surface, beneath which the hind-limbs can be concealed. All the forms are confined to the Old World; and while one of the three genera is Indian, the other two are African. The Indian genus *Emyda* is readily characterised by the presence of a complete series of neural bones in the carapace, coupled with a semicircle of marginal bones at its hinder extremity. In neither of the three living species does the length of the shell and its soft disc exceed 10 inches, but much larger fossil forms are found in the Pliocene rocks of India. Both the African genera lack marginal bones, but whereas in one (*Cycloderma*) there is a full series of neural bones to the carapace, in the other (*Cyclanorbis*) these form an incomplete and interrupted series.

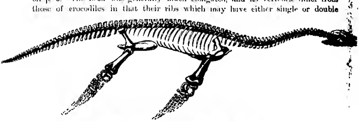
Habits. All the soft-tortoises are thoroughly aquatic, most of them but rarely leaving the water except for the purpose of laying their eggs and in consequence of these habits very little is known as to their mode of life. Although confined as a rule to rivers, a few of the species frequent estuaries, and Cantor's soft-tortoise has been found some distance out at sea. Occasionally, again, specimens of the Indian granulated soft-tortoises have been met with wandering on land far from the neighbourhood of water. Fiercer and more spiteful than any other members of the Chelonian order, these tortoises, owing to a peculiarity in the structure and mode of articulation of some of the vertebræ of the neck, have the power of darting out the head with inconceivable rapidity, the great Indian chitra being *facile princeps* in this respect. Owing to this habit the larger species are dangerous creatures to approach incautiously, as their bite is very severe; and the natives are not unfrequently bitten by them in India and Burma whilst bathing. All the members of the typical genus, together with Cantor's soft-tortoise and the chitra, are known to be carnivorous, and it is commonly believed that the same is the case with the other members of the group. According, however, to Dr J. Anderson, this is incorrect with regard to the granulated soft-tortoises of India, which he expressly states to be exclusively vegetable and grain-feeders. The larger species probably feed both on fish and other aquatic animals, and on the flesh of such carcases as may be floating in the rivers they inhabit. In correlation with their asserted herbivorous habits, the small granulated species do not snap and bite after the manner of their larger cousins. On shore, according to the observer last mentioned, when left to themselves, these species will slowly and cautiously extend their necks, and when approached, instead of attempting to escape, withdraw rapidly into their shells, of which the upper and lower anterior margins then meet. It is stated that all the species are chiefly nocturnal, remaining during the daytime partially or completely buried in the mud at the bottom of the water, and not beginning to swim till sundown. Such species as inhabit marshes or swamps, liable to be dried up during the hot season, bury themselves in the mud, at no great depth below the surface, during the period of drought. As these tortoises are known to remain frequently for a period of from two to ten hours, and occasionally as much as fifteen hours, beneath the water, without coming to the surface to breathe, it is obvious that they must have some special means of oxygenating their blood. It is probable, indeed, that certain filamentous appendages of the mucous membrane of the throat found in these tortoises subserve the office of gills, and thus enable the blood to be renovated by means of the atmospheric air dissolved in the water they inhabit. With regard to their breeding-habits, it appears that the females of the granular shelled species scrape a shallow hole in the mud, in which the eggs are laid and then carefully covered up, the eggs themselves being round, and about an inch in diameter.

THE PLESIOSAURS OR LONG-NECKED MARINE LIZARDS.

Order SAUROPTERYGIA.

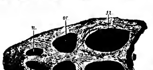
Strikingly different in appearance as are the skeletons of the members of the two groups, it appears that, on the whole, the nearest allies of the tortoises and turtles are those extinct reptiles known as plesiosaurs, or long-necked marine lizards, whose range in time embraced the whole of the great Secondary period, during which were deposited the vast series of strata extending from the Chalk downwards through the Oolites to the Lias and Trias. These reptiles agree with the tortoises in that all or nearly all of the ribs of the back are articulated to the vertebræ by single heads, and in the absence of hook-like (uncinate) processes to the ribs, as well as in the want of a breast-bone or sternum. In the skull the quadrate-bone is immovably fixed, and the palate more or less completely closed. Both groups have the lower bones of the pelvis expanded into large flat plates, and there is also a similarity in the structure of the bones of the limbs.

Whereas, however, the tortoises have the upper surface of the body covered with a shell, and the lower aspect of the same protected by a plastron, the plesiosaurs were entirely naked, the plastron being represented by a numerous series of abdominal ribs, each composed of three pieces, forming a forwardly-directed angle. The skull differs from that of the crocodiles in having but one (lower) temporal arch; and the jaws are furnished with a number of pointed and grooved teeth, implanted in distinct sockets; one of such teeth being figured on p. 5. The neck was generally much elongated, and its vertebræ differ from those of crocodiles in that their ribs which may have either single or double heads, are articulated only to the body of each vertebra (as shown in the accompanying figure); those of crocodiles always having two heads, of which the lower is articulated to the body, and the upper to the arch of the vertebra. Throughout the backbone the bodies of the vertebræ have either nearly flat or slightly cupped articular surfaces, and in the region of the back each pair of ribs is articulated to a process arising from the arch of each vertebra, instead of from a facet placed at the junction of two vertebræ, as in the tortoises. Although there are other interesting features in these reptiles, those mentioned distinguish them from crocodiles and dinosaurs on the one hand, and tortoises and turtles on the other.



RESTORED SKELETON OF A PLESIOSAUR (greatly reduced).

With regard to the various groups into which the order is divided, it may be mentioned that in the typical forms, constituting the family *Plesiosauridæ*, the limbs, as shown in the figure on p. 102, are converted into flattened paddles, with a shortening of the bones of the upper segments, and an increase in the number of bones corresponding with those of the toes of ordinary reptiles. In the true plesiosaurs (*Plesiosaurus*) of the Lias, the ribs of the neck were articulated to the vertebræ by two heads, whereas in the later cimoliosaurs (*Cimoliosaurus*) of the Oolites and Chalk such ribs, as shown in the figure of a neck-vertebra, were single-headed. Some of these creatures were of huge size, attaining a length of between 30 and 40 feet; certain of the species

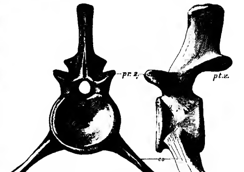


UPPER SURFACE OF THE SKULL OF THE SIMOSAUR, OR TRIASSIC PLESIOSAUR.

n, nostrils; *or*, eye-sockets; *st*, temporal fossæ (½ nat. size).—From Gaudry.

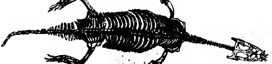
from the Cretaceous strata having a neck much exceeding the body and tail in length, and containing as many as forty vertebræ. Marine and carnivorous in their habits, these formidable creatures probably lurked in shoal-water, from whence they darted their long necks to seize passing fishes in their jaws. In the groups mentioned the head was comparatively small, but in the huge pliosaurs (*Pliosaurus*) of the upper Oolitic strata the skull was of enormous size, attaining in some instances a length of 6 feet, and the neck proportionately short and thick. Their teeth had more or less triangular crowns, and in some cases inclusive of the root, measured quite a foot in length.

As is the case with all the higher aquatic Vertebrates, there is evidence to show that the plesiosaurs were originally derived from land animals; the representatives of the group found in the earlier (Triassic) Secondary rocks having limbs departing much less widely from the ordinary type, and bearing claws at the extremities of their digits. In the small lariosaur, which measured about a yard in length, the limbs appear to have been somewhat intermediate in structure between the clawless paddles of the true plesiosaurs and those of more ordinary reptiles; and the creatures were probably amphibious in their habits, spending part of their time on land, and part in the water. In the allied nothosaurs and simosaurs the limbs were better adapted for walking, from which we may infer that their owners were still more terrestrial in their habits.



FRONT AND SIDE-VIEWS OF A NECK-VERTEBRA OF A PLESIOSAURIAN.

pr.z, and *pt.z*, anterior and posterior articular surfaces of the arch; *co*, rib.



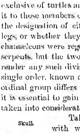
UPPER ASPECT OF THE SKELETON [illegible]SAUR, A SMALL PLESIOSAURIAN

CHAPTER IV.

SCALED REPTILES.—LIZARDS AND CHAMÆLEONS,—Order SQUAMATA; Suborders LACERTILIA AND RHIPTOGLOSSA.

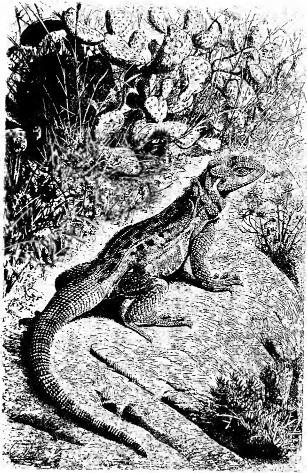
ALTHOUGH in popular language the term lizard is applied to any four-legged reptile exclusive of turtles and crocodiles, in scientific usage it is more convenient to restrict it to those members of the great group of scaled reptiles which do not come under the designation of either chamæleons or serpents, whether they are provided with legs, or whether they lack those useful appendages. Formerly, indeed, lizards and chamæleons were regarded as constituting an order by themselves quite apart from serpents, but the two groups are now known to be so intimately connected as to render any such division inadmissible; and they are accordingly here placed in a single order, known as scaled reptiles, or, technically, Squamata. Structurally, this ordinal group differs very widely indeed from any of those hitherto treated, and as it is essential to gain a correct idea of such structural differences, they may first be taken into consideration.

Skull. Taking their name from the coat of overlapping horny scales with which they are generally invested, the scaled reptiles are primarily distinguished from all the foregoing groups by the circumstance that the quadrate-bone is more or less movably articulated to the skull, and has its lower end projecting freely therefrom instead of being immovably wedged in among the other bones. To this primary point of distinction it may be added that the lower temporal arch of the skull is wanting, so that there is no bony bar connecting the lower end of the quadrate-bone with the upper jaw, as there is in the crocodiles: the absence of this bar being well shown in the figure of a lizard's skeleton. Then, again, the palate, instead of being more or less completely roofed over by bone, is largely open, its bones taking the form of long bars. In some lizards, as in the one of which the skeleton is figured, the upper surface of the skull is covered by bone, so that the temporal fossæ are roofed over.



LEFT SIDE OF THE VERTEBRA OF A SNAKE.

Ribs and Vertebræ. Another important feature of the order is to be found in the circumstance that the ribs in the region of the back are single-headed, and are articulated to the backbone by means of a facet (*d*) situated on the body of each vertebra. This feature at once distinguishes the order from the crocodiles and dinosaurs, in which the ribs are two-headed, and in the back articulate to a



ROUGH-TAILED AGAMA BASKING.

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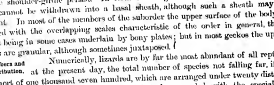
long process arising from the arches of the vertebræ; from the tortoises, where the single-headed ribs articulate at the junction between the bodies of two vertebræ; and from the plesiosaurs, in which the single-headed ribs of the back are articulated to processes or facets on the arches of the vertebræ. In most of the members of the order the body of each vertebra has a cup in front and a ball behind, by which it articulates with the adjacent segments of the column—an arrangement paralleled among modern crocodiles. In some lizards, and in all snakes, the vertebræ, as shown in the figure on p. 6, have additional surfaces on their arches for mutual articulation, thus communicating additional flexibility, and at the same time strength to the backbone.

Other Characters. Another important feature in which the order differs from all the preceding ones, is the absence of any system of true abdominal ribs, or of their equivalent, a plastron, on the inferior surface of the body. As regards the teeth, these differ from those of the orders hitherto considered in that, instead of being implanted in separate sockets, they are firmly soldered to the bones of the jaw. In some cases they are attached to the very summit of the jawbones, when the dentition is said to be *acrodont*; while in others they are affixed to one of the side-walls of the free edges of the jaws, the term *pleurodont* being then employed. Another divergence from both crocodiles and tortoises is to be found in the vent opening by a transverse aperture, whereas in the former group it is longitudinal, and in the latter either circular or longitudinal. Finally, in those forms in which the bones of the chest attain their fullest development, there is a breast-bone or sternum, a pair of collar-bones or clavicles, and a median T-shaped interclavicle.

Special Characters of Lizards. The above being the leading characters of the entire order of scaled reptiles, it remains to consider how the lizards (Lacertilia) are to be distinguished from the other two suborders into which the existing members of the assemblage are divided. Externally, by far the greater number of lizards are four-limbed reptiles of a crocodile-like appearance, with the head, neck, body, and tail well distinguished from one another, and if we had these alone to deal with, there would be no sort of difficulty in distinguishing between a lizard and a snake. The matter is, however, somewhat complicated by the circumstance that certain lizards, like the familiar slow-worm, lose all external traces of limbs, and assume an elongated snake-like form, with the head passing imperceptibly into the body without the intervention of a distinct neck, and without any external indication of where the body ends and the tail commences. Externally, such snake-like lizards are very difficult to distinguish from snakes, but on opening the mouths of the former it will be found that the tongue cannot be withdrawn into a sheath at its base, as is always the case with the latter. Further help in discriminating between the two is afforded by the circumstances that whereas snakes have neither eyelids nor external ear-openings, both these are usually, although not invariably, present in the limbless lizards. As additional distinctive features of the present group, by means of which they can be distinguished both from snakes on the one hand and from chamæleons on the other, the following points may be noticed. In all lizards the two branches of the lower jaw are united at the chin by means of a bony suture; while in all the species furnished with limbs collar-bones are present; and when the limbs are absent, some traces of the bones forming what is known as the shoulder-girdle persist. In form the tongue is flattened, and, as already said, cannot be withdrawn into a basal sheath, although such a sheath may be present. In most of the members of the suborder the upper surface of the body is clothed with the overlapping scales characteristic of the order in general, these scales being in some cases underlain by bony plates; but in most geckos the upper scales are granular, although sometimes juxtaposed.

Numbers and Distribution. Numerically, lizards are by far the most abundant of all reptiles at the present day, the total number of species not falling far, if at all, short of one thousand seven hundred, which are arranged under twenty distinct families. In this abundance at the present day, coupled with the specialised features of the greater part of their organisation, lizards may be regarded as occupying a very similar position in the reptilian class to that held by the perching birds in the preceding class. With the exception of the polar and subpolar zones, lizards are distributed over the whole globe, ranging in some districts from the level of the sea to the limits of eternal snow, and found alike in fruitful and barren districts, in the neighbourhood of water, and in the most arid deserts. Whereas, however, in the colder regions they are poor in species and small in size, it is in the tropics and subtropical regions that they attain their maximum development, as regards numbers, bodily size, richness of coloration, and peculiarity of form.



SKELETON OF LIZARD.

As regards their distribution over the surface of the globe, lizards present a most remarkable difference from what obtains among Amphibians (frogs, newts, etc.), and, to a less degree, among tortoises. For instance, whereas Amphibians, and to some extent tortoises, have their distributional areas defined equatorially, such lines of division, in the case of the present group, must be drawn meridionally. Thus, in the case of Amphibians, one great distributional province includes Europe, Asia, and North America, and the second embraces the regions lying south of the Equator; whereas in the case of lizards one area marked by peculiar forms will include the Old World and Australia, and the other will comprise the whole of America. As has already been noticed, the distribution of tortoises approximates to the former type, all the side-necked group being confined to the Southern Hemisphere. Again, we find that whereas Tropical Africa is closely related to

Tropical India as regards its Amphibians, while Australia and Africa are near akin to South America in regard to their tortoises, in respect of lizards there is no close connection between India and Africa, but an intimate relationship exists between India and Australia, where members of the same genera occur; while the Australian lizards are totally unlike their South American cousins. As might have been expected from their great numerical preponderance at the present day, lizards appear to be a comparatively modern group, their remains being rare in the lower Tertiary deposits, while in the Secondary period they are only known by a few species from the rocks of the Cretaceous epoch. That the group has originated from the tuateras, which were so abundant in the earlier strata of the Secondary period, may be regarded as most probable.

Habits. Turning to their mode of life, we find that while a few members of the order resemble crocodiles, in spending the greater portion of their time in water, visiting the land only for the purposes of feeding, sleeping, or basking in the sun, by far the great majority of lizards are essentially land-animals, avoiding even damp situations. Although some inhabit trees, the greater 2 number dwell either on the ground or among the clefts of rocks; the conformation of the body generally giving some indication of this diversity of habitat. Among the land forms, for instance, those with depressed bodies are generally to be found in open sandy deserts, where they seek shelter either beneath stones or in holes, whereas such as have the body compressed are more usually dwellers among bushes or in trees. Those, again, in which the body is more or less cylindrical, are in the habit of secreting themselves in the clefts of rocks or the chinks of tree-stems, while the snake-like kinds live on the ground, and those with a more worm-like form beneath its surface. The movements of the greater number of species—whether they live on the ground, among rocks, on trees, or on cliffs or walls—are agile in the extreme; and while the majority run with their bodies close to the ground, many habitually raise themselves up at times by resting on their hind-legs and tails, and are able to spring, either on the ground or from branch to branch, to a considerable distance after their prey. Of the arboreal species, some make use of their tails to aid in maintaining their hold, while others, together with cliff- and wall-hunting species, like the geckos, are enabled to run along the under sides of boughs, or to ascend vertical surfaces by the aid of their expanded and disc-like feet. The peculiar flying lizard is enabled to take long, flying leaps, supported by a parachute-like membrane borne by the expanded ribs; while all the limbless species move somewhat after the manner of snakes, although making less use of the extremities of the ribs. The few aquatic forms swim and dive without the aid of webbed feet, but many other kinds swim well if thrown into water.

In many cases elegant and graceful in form, although at others rendered more curious than beautiful by the presence of spines or warts, lizards are pleasing rather than repulsive animals; and, with the exception of the American heloderms, none are poisonous, although some will bite sharply. Few lizards possess a distinct voice, the majority merely uttering a low hiss; some, however, especially among those whose habits are nocturnal—emit a clear, sharp cry, which has been likened both to the scream of a frog, and to the chirp of a cricket. Of their senses, the most acute is doubtless that of sight, next to which probably comes hearing. In regard to diet, a few lizards are strictly herbivorous, but the great majority are more or less completely carnivorous; the larger kinds feeding on small mammals, birds and their eggs, other reptiles, and, more rarely, frogs and fish, as well as many descriptions of invertebrates. The smaller members of the order, on the other hand, are restricted mainly or entirely to an invertebrate diet, the great portion of which consists of insects, worms, and land-molluscs. Nearly all drink by rapidly protruding and withdrawing the tongue; dew affording sufficient moisture to those living on rock or in trees, while some kinds can exist for long periods, or even entirely without drinking. The species inhabiting the warmer regions, save those which are arboreal or aquatic in their habits, pass the hottest and driest season of the year in a state of torpor; while those in colder regions regularly hibernate, such hibernation, in the case of some of the species inhabiting the continent of Europe, lasting for a period of from six to eight months. As regards their breeding-habits, the majority of lizards lay eggs, which may vary from two to thirty in number, and have generally a soft and leathery covering, although sometimes furnished with a hard calcareous shell.

One peculiarity characterising the members of the order cannot be passed over before concluding these introductory remarks. This is the facility with which they are enabled to reproduce lost parts, and more especially the tail. As is well known, in many lizards, when handled, the tail breaks off without any rough usage, and in all or nearly all it will readily come in two if pulled when the creature is seeking to escape, this susceptibility to automatic fracture being due to a cartilaginous band across the middle of each vertebra of the tail in the case of the common lizard of England. Such missing portion of the tail is speedily reproduced, it may be double; and whereas among the members of the typical family of the order, the scaling of the reproduced portion is like the original, in certain other forms this is by no means always the case. The remarkable circumstance about the matter is that when the pattern of the scaling of such a new tail differs from the original, it always reverts to that characterising a less specialised and probably ancestral group. It is scarcely necessary to mention that in such an extensive assemblage as the present, only a comparatively small percentage of species, or even genera, can be mentioned, and these but briefly.

THE GECKOS

Family *GECKONIDÆ*.

Few creatures have given rise to a greater amount of fable and legend than the large group of lizards commonly known as geckos; such legends being probably due to the nocturnal and domestic habits of these creatures, coupled with the sharp chirping cry from which they derive their name, and their curiously expanded disc-like toes. Absolutely innocuous, they have been credited from the earliest times with ejecting venom from their toes, and of poisoning whatever they crawled over, while the teeth of one species have been asserted to be capable of leaving their impression on steel. Indeed, so intense is the dread inspired by these little creatures, that in Egypt the lobe-footed, or fan-footed species is commonly termed *abou-burs*, or father of leprosy.

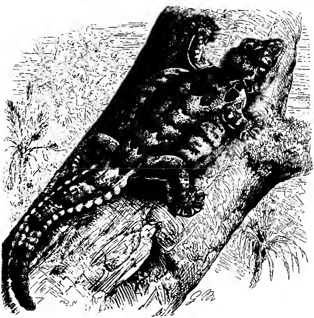
Geckos, of which there are some two hundred and eighty species, distributed over all the warmer parts of the globe, although more numerous in the Indian and Australian regions than elsewhere, are for the most part small and plumply-built nocturnal lizards, characterised by their depressed form and dust-like coloration. The rather long and more or less flattened head is broad and triangular in shape; the large eyes are characterised by the absence of movable lids, and by the pupil being, except in a few diurnal forms, vertical; while the aperture of the ears is likewise in the form of an upright slit. Externally, the head is covered with minute granules, or small scales, and the body is devoid of a bony armour, and in most cases covered above with granules, and beneath with small overlapping scales. If we add to the above features that the tongue is either smooth or covered with villous papillæ, and is short or moderate in length, and not sheathed at the base, and that the bodies of the vertebræ articulate together by means of cup-shaped surfaces at both their extremities, we shall have said sufficient to distinguish the geckos from all other members of the suborder. As regards their other external characters, the neck is very short and thick, the body, although rounded, markedly depressed, and the tail, which is generally remarkably brittle, usually thick and of moderate length, with its basal portion either cylindrical or laterally compressed, although it may be leaf-like, or even rudimental. In some cases the tail is known to be prehensile, and it is not improbable that it is frequently endowed with this power. The limbs are generally remarkable for their shortness, and are always provided with five toes each, the tips or sides of which may be more or less dilated. In those species inhabiting desert regions, the toes are of normal form, being often nearly cylindrical, and keeled on their lower surfaces; but in the great majority of the members of the family, they are expanded either throughout their length or partially into adhesive discs, of which the under surface is formed by a series of movable symmetrical plates of variable form, by the aid of which the creatures are enabled to ascend walls and run across the ceilings of rooms. In some cases the claws are retractile, either within the plates of the discs, or into sheaths; while in other instances the toes may be united by webs, which are not, however, for the purpose of swimming, all the geckos being land-lizards. The numerous teeth are small, and attached to one side of the summit of the jaw (pleurodont).

LOBE-FOOTED GECKO.

Lobe-Footed Gecko. The geckos being so numerous in species, which are arranged under no less than forty-nine genera, it is of course impossible in a work like the present to do more than notice a few of the better known or more striking. Among these, one of the most familiar is the little lobe- or fan-footed gecko (*Ptyodactylus lobatus*), of Northern Africa, Arabia, and Syria. This is one of two species belonging to a genus characterised by the toes (as shown in the figure on p. 111) being dilated at their summits, where they are furnished inferiorly with two diverging series of plates: the digits being furnished with claws capable of retraction within notches in the front of the disc. The upper surface is covered with granules, among which are some small keeled tubercles; the colour being greyish or yellowish brown above, with darker and light spots, and below uniform white. The length is a little over 5 inches.

TURKISH GECKO (nat. size).

Turkish Gecko. Equally well known is the Turkish gecko (*Hemidactylus turcicus*), represented in the figure above, which is likewise a small species, inhabiting the countries bordering the Mediterranean and Red Seas, and also found in Sind. It belongs to a group of genera with dilated toes and compressed claws, and is specially characterised by the extremities of the toes being free, the plates on the under surface of the discs arranged in double rows, and the presence of some large shields on the under surface of the tail. Measuring not more than 4 inches in length, this species may be distinguished from the other



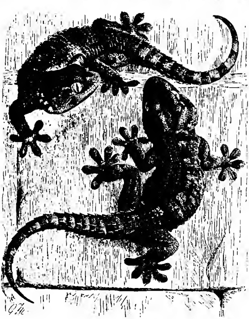
FRINGED GECKO (nat. size).

European geckos by the body being covered with from fourteen to sixteen longitudinal rows of warts of which some are white and the others blackish, and likewise by the hue of the upper-parts being greyish brown spotted with flesh-colour. It is, however, said to be able to change its colour according to circumstances, being of a shining milky white at night, and dark-coloured during the daytime. The genus to which it belongs comprises over thirty species, ranging over Southern Europe and Asia, Africa, Tropical America, and Oceania.

Fringed Gecko. A larger and more remarkable species is the one represented in the illustration on p. 113 (*Ptychozoon homalocephalum*), which is the sole member of a genus characterised by the presence of an expansion of skin along the sides of the body, continued as lobes on the tail, as well as by the toes being completely webbed, and the inner one devoid of a claw. Attaining a length of nearly 8 inches, this species has a distinctly ringed tail; its colour above being greyish or reddish brown, marked with undulating dark brown transverse bands and a dark streak extending from the eye to the first of the bands on the back. This gecko is an inhabitant of Java, Sumatra, Borneo, and the Malay Peninsula.

Wall-Gecko. The last member of the family we shall specially notice is the wall-gecko (*Tarentola mauritanica*), which is the Mediterranean representative of a small genus ranging from the countries bordering the Mediterranean to West Africa, and including one West Indian species. The genus is readily recognised by all the toes being dilated, and only the third and fourth furnished with claws. This species varies from rather less than 5 to somewhat more than 6 inches in length, of which one-half is formed by the tail. The sides of the neck and body, as well as the upper surface of the limbs, are ornamented with conical tubercles; the back carries seven or nine longitudinal rows of larger and strongly-keeled tubercles; and on the anterior half of the tail the ornamentation takes the form of knobs with backwardly directed spines. The general colour of the upper-parts is greyish brown, with more or less distinct lighter and darker marblings, while a well-marked dark streak passes on each side of the head through the eye.

Habits. With the exception of a certain number of species, the geckos, as already said, are nocturnal in their habits, and many are remarkable for uttering shrill cries, probably produced by striking the tongue against the palate, which in some cases are compared to the syllables *gecko*, *checko*, or *toki*, and in others to the monosyllable *tok*. A South African sand-gecko is at times stated to occur in such numbers, and to produce such a din by its cry, as to render a sojourn in the neighbourhood well-nigh insupportable. As regards their habitat, geckos are very variable, some frequenting arid deserts, where they, in some instances, burrow in the sand; others frequent wooded regions, living either among low bushes or on trees, and concealing themselves during the day beneath stones or the bark of the stems; others again are found among rocks; while a third group has elected to live among human dwellings, where some of its members have become as fearless and confiding as domesticated animals. Of the arboreal species, the frilled gecko is peculiar in having a parachute-like expansion of skin, which is used after the manner of that of the flying squirrels in aiding its owner to take long leaps from bough to bough. When at rest, the parachute is kept close to the sides of the body by the aid of its intrinsic muscles; and it is stated that this species, like several others, has the power of changing its colour according to the hue of the object in which it is resting. The species frequenting houses may be divided into those which resort to the interior, and those which are content with the outside. Of the latter, Sir J. E. Tennent writes that in Ceylon, "as soon as evening arrives, geckos are to be seen in every house in keen and crafty pursuit of



WALL-GECKOS (nat. size).

their prey: emerging from the chinks and recesses where they conceal themselves during the day, to search for insects that then retire to settle for the night. In a boudoir, where the ladies of my family spent their evenings, one of these familiar and amusing little creatures had its hiding-place behind a gilt picture-frame. Punctually as the candles were lighted, it made its appearance on the wall to be fed with its accustomed crumbs: and, if neglected, it reiterated its sharp quick call of *chic, chic, chit*, till attended to. It was of a delicate grey colour, tinged with pink; and having by accident fallen on a work-table, it fled, leaving part of its tail behind it, which, however, it reproduced within less than a month. . . . In an officer's quarters, in the fort at Colombo, a gecko had been taught to come daily to the dinner-table, and always made its appearance along with the dessert. The family were absent for some months, during which the house underwent extensive repairs, the roof having been raised, the walls stuccoed, and the ceilings whitened. It was naturally surmised that so long a suspension of its accustomed habits would have led to the disappearance of the little lizard; but on the return of its old friends it made its entrance as usual at their first dinner, the instant the cloth was removed." Another Indian observer, Colonel Tytler, writing of these house-geckos states that although several species "may inhabit the same locality, yet, as a general rule, they keep separate and aloof from each other; for instance, in a house the dark cellars may be the resort of one species, the roof of another, and the crevices in the walls may be exclusively occupied by a third species. However, at night they issue forth in quest of insects, and may be found mixed up together in the same spot; but on the slightest disturbance, or when they have done feeding, they return hurriedly to their particular hiding-places." So far as is known, all the members of the family agree with the house-geckos in being insectivorous. With the exception of two peculiar New Zealand species producing living young, all the geckos appear to lay eggs, which are enclosed in a round and hard shell, and are generally two in number.

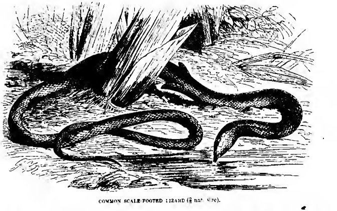
Eyelid Geckos. A few peculiar geckos, assigned to three genera and of which Hardwicke's gecko (*Eublepharis hardwickei*) is one of the best known examples, differ from the true geckos in being furnished with movable eyelids, and also in that their vertebræ are articulated together by means of cup-and-ball joints. Consequently, these eyelid geckos, as they may be termed, form a distinct family—*Eublepharidæ*.

THE SCALE-FOOTED LIZARDS.

Family *PYGOPODIDÆ*.

To the ordinary observer it might well appear that the whole of the snake-like lizards, or those in which the body has become cylindrical and much elongated, and the limbs either rudimentary or wanting, would pertain to a single family. Such, however, is not the view of modern zoologists, who regard many of these abberrant members of the suborder as having been independently derived from several groups of fully limbed forms, and thus having but little relationship among themselves. Of these snake-like groups, one of the most remarkable is that of the scale-footed lizards of Australia and New Guinea, which form a family comprising six genera, all characterised by the retention of more or less well-marked rudiments of the hind-limbs, although the front pair have quite disappeared externally. According to the opinion of Mr. Boulenger, the scale-foots come nearest to the geckos, with which they agree in the essential characters of their skull, as they do in the nature of their tongue, the want of movable eyelids, and the vertical pupil of the eye; although the latter character, as being variable in the geckos, cannot be regarded as of much importance. Apart from their external form, they differ from the geckos and thereby resemble the members of the next family in that the inner extremities of the collar-bones are not expanded into a loop-shaped form, while they are peculiar in that the number of bones entering into the composition of each half of the lower jaw is reduced from six to four. The small and numerous teeth are closely set, and have generally long, cylindrical shafts, and blunted summits; although in the genus *Lialis* they are sharply pointed, swollen at the base, and backwardly curved, thus resembling those of the monitors. The hinder limbs are represented externally by a scaly flap, which is most developed in the genus to which the figured example belongs, the component bones may be felt more or less distinctly, and the skeleton of the common species shows five toe-bones.

The common scale-foot (*Pygopus lepidopus*), which attains a length of about 20 inches, and has a tail twice as long as the head and body, is the typical representative of the few members of this family. The head is long pointed at the snout, and scarcely separated from the body, being covered above with large symmetrical shields, and on the sides with small scales. The ear has an oblique oval aperture, and the rudimental immovable eyelids are circular and covered with minute scales. The cylindrical body is slender and of nearly equal thickness throughout, the scales on its upper surface, as in that of the long tail, being keeled.



COMMON SCALE-FOOTED LIZARD (⅔ nat. size).

Larger in males than in females, the limbs have rounded extremities, and are enveloped in overlapping scales. In general colour, this lizard is coppery grey above, sometimes marked with three or five longitudinal rows of blackish dots or elongate spots; the under-parts being marbled grey, with the exception of the throat, which is white. Found both in Australia and Tasmania, and by no means uncommon in the warmer northern parts of Victoria, this lizard, like its kin, is stated to have habits very similar to those of the blind-worm, although accurate observations on its mode of life are wanting.

THE AGAMOID LIZARDS.

Family *AGAMIDÆ*.

The southern and eastern portions of the Old World are the home of a very extensive family of lizards, comprising thirty genera and over two hundred species, which may be conveniently termed agamoids, from the name of the typical genus. Agreeing with the preceding families in the characters of the tongue, and in the absence of bony plates beneath the scales, the agamoids resemble the scale-foots in the characters of their collar-bones; but are distinguished from all their allies in having teeth of the acrodont type, that is to say, situated on the very summit of the edges of the jaws. While the head is covered with small scales, the small eyes have circular pupils, and well-developed movable eyelids; and the scales on the back are of the normal overlapping type. The thick tongue is either completely attached or only slightly free in front, and, at most, has but a very shallow notch in its tip. The teeth may be generally divided into three series, comparable as regards position with the incisors, tusks, and molars of mammals; the latter being more or less compressed, and frequently furnished with three cusps; while the tusks, which may be one or two in number on each side, are of relatively large size in most cases although occasionally absent. The fore-limbs are always well developed, and, except in one genus, five-toed. The absence of large symmetrical horny shields, both on the head and under-parts, is a noteworthy character of these lizards, many of which develop, either in the males or in both sexes, ornamental appendages, such as crests or pouches. As a rule, the tail is long and not brittle, but in only one genus is it prehensile, although in another it can be curled up at the extremity. The shape of the body is very variable in the different genera, the terrestrial forms being generally depressed, while those that are arboreal in their habits are compressed. Although the majority of the species are insectivorous, some subsist on leaves and fruits, while others prefer a mixed diet; but neither the nature of their habitat nor their food serve to classify the agamoids, many of the genera of which are very difficult to distinguish. The majority of the species appear to lay eggs, only the members of a single genus being reported to give birth to living young. As regards distribution, agamoids are found from the south of Europe to the Cape and eastwards as far as China, the Malayan Islands, Australia, and Oceania, but are unknown in New Zealand and Madagascar. Both as regards genera and species, their headquarters is, however, the Oriental region; Africa possessing only three genera, of which one is confined to the northern part of the continent, while but four species enter South-Eastern Europe.

Flying Lizards.

Commonly known as flying dragons, the members of the first genus of the family are elegant and harmless little creatures to whom such a title seems inappropriate, and we therefore prefer to substitute the name of flying lizards—more especially as we have applied the former appellation to the extinct pterodactyles. These flying lizards, which are represented by twenty-one species, ranging over the greater part of the Oriental region, are at once distinguished from all their kindred by the depressed body being provided with a large wing-like membranous expansion, supported by the elongated extremities of the six or seven hinder ribs, and capable of being folded up like a fan. The throat is furnished with a large membranous expansion, on the sides of which are a smaller pair; and the tail is long and whip-like. The best known of the species is the Malay flying lizard (*Draco volans*), which is a rather common form, and belongs to a group characterised by the nostrils being lateral and directed outwards; this particular species being distinguished by the absence of a spine above the eye, by the aperture of the ear being smaller than the eye, and by the inferior surface of the parachute being ornamented with black spots. In addition to the appendages on the throat, the males have a small crest on the nape of the neck; while in both sexes the back is covered with irregular, large-keeled scales, and its sides have a series of still larger scales, which are also keeled. In length it measures a little over 8 inches. As regards coloration, the upper-parts are of a brilliant but variable metallic hue, ornamented with small dark spots and wavy cross bands, between the eyes is a black spot, and a similar one occurs on the nape, the parachute is orange, with marblings or irregular crossbands of black; and the throat is mottled with black, its appendage being orange in the male and bluish in the female. This lizard inhabits the Malay Peninsula, Sumatra, Java, and Borneo, and in the living state is described as being so superlatively beautiful as to baffle description.

Essentially arboreal in their habits, the flying lizards generally frequent the crowns of trees, and as they are comparatively scarce, and seldom descend to the ground, they are but rarely seen. Describing the habits of the Malayan species, Cantor says that "as the lizard lies in shade along the trunk of a tree, its colours at a distance appear like a mixture of brown and grey, and render it scarcely distinguishable from the bark. There it remains with no signs of life, except the restless eyes, watching passing insects, which, suddenly expanding its wings, it seizes with a sometimes considerable, unerring leap. The lizard itself appears to possess no power of changing its colours." When excited, the appendages on the throat are expanded or erected; and the ordinary movements of the creature take the form of a series of leaps. After commenting on the fact that both flying lizards and flying lemurs inhabit the same countries, and have very similar modes of life, Moseley states that, when springing from branch to branch and from tree to tree, the former pass so rapidly through the air that the expansion of the parachute almost escapes notice. Some examples kept on board ship were in the habit of flying from one leg of a table to another. The females appear to lay three or four oval whitish eggs. What about these lizards.

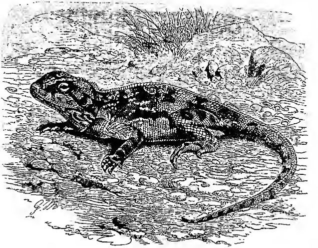
Oriental Tree Lizards. Among a number of genera, characterised by their more or less compressed bodies and generally arboreal habits, the numerous tree-lizards constituting the genus *Calotes* may be selected for brief mention. These beautiful lizards belong to a group distinguished from many of their allies by the aperture of the ear being open, while they are especially characterised by the absence of any distinct fold of skin across the throat, by the equality in size of the large keeled scales on the back, and the presence of a large crest on the back and neck; the tail being very long and whip-like. One of the best known species is the variable lizard (*C. versicolor*), ranging from Baluchistan, India, and Ceylon to the south of China, an exceedingly handsome lizard of some 16 inches in length, with a very large crest, but so variable in colour, when alive, as almost to defy description. It is one of the commonest of the eastern Asiatic lizards, and derives its name from its power of changing colour, which is especially marked when it is sitting basking in the sun; the head and neck being often yellow, flecked with red, the body red, and the limbs and tail black. When irritated, or feeding rapidly, an allied species (*C. ophiomachus*), from India and Ceylon, turns brilliant red over the head and neck, the body at the same time becoming pale yellow; hence it is popularly known as the "blood-sucker."

Ceylon Horned Lizards. Three remarkable lizards from Ceylon, constituting the genus *Ceratophora*, and belonging to a group in which the aperture of the ear is concealed, derive their name from carrying a more or less elongated horn-like process on the nose, at least in the male sex; the neck and back being devoid of a crest. One of the species, which attains a length of about 10 inches, has a horn measuring half an inch. These lizards appear to be very rare, one of the species being confined to mountain districts.

True Agamas. For want of a distinct English title, we are compelled to designate the members of the genus *Agama* collectively by anglicising their scientific name. Distinguished from all the previously noticed forms and their allies, with the exception of the flying lizards, by their more or less depressed bodies, agamas are especially characterised by the exposed aperture of the ear, and the presence of large callous scales in front of the vent in the males. The crest on the back is, at most, but small, and may be wanting; while each side of the throat has a pit, and there is likewise a transverse fold across this part. A sac-like appendage may or may not occur beneath the throat, and the moderately long tail may be either cylindrical or slightly compressed. Less important characters are to be found in the form of the head, which is short and triangular, very broad behind, and rounded at the muzzle, as well as in the relative length and slenderness of the limbs. The head is covered above with small smooth scales; those on the back are overlapping and keeled; while on the tail the scales may be either simply overlapping or arranged in whorls.

The distribution of the genus is somewhat peculiar, impinging on South-Eastern Europe, and embracing the greater part of South-Eastern Asia, as well as the whole of Africa, but excluding India proper, together with Ceylon and Burma, although including the Punjab, Sind, and the Himalaya. As indicated by their depressed bodies, agamas are mainly ground-lizards, generally frequenting barren localities or rocks, although a few species resort to shrubs. The circular pupil of their eyes is equally indicative of diurnal habits; and a large number of species are fond of basking on rocks in the full glare of the sun. In such situations, as in the valleys around Kashmir, they may be seen in numbers on almost every roadside mass of rock, where their extreme agility renders them very difficult to capture; the best method, according to the writer's experience, when specimens are required for preservation, being to strike with the lash of a hunting-whip, whereby they are instantaneously stunned or killed. As regards food, all appear to be insectivorous.

Armed Agama. From among rather more than forty representatives of the genus, three are selected for especial notice. The first of these is the armed agama (*A. armata*) of South Africa, which is represented in the figure opposite, and attains a total length of some 20 inches, of which rather more than 6 are occupied by the tail. Belonging to the second great group of the genus, or that in which the occipital or hindmost median scale on the top of the head is enlarged, this species is characterised by the spinose scales on the back being of unequal size, by the aperture of the ear being larger than the eye, by the fifth toe being as long as the first, and the third slightly longer than the fourth, as well as by the scales on the abdomen being keeled. Both sexes have a low crest on the nape of the neck, whereby the species is distinguished from most of its South African congeners; while the males have two rows of twelve thickened horny scales in front of the vent. Although variable, this handsome lizard is strikingly coloured. Generally the upper-parts are olive-brown, with the enlarged scales lighter; and there is a double series of darker blotches along the back; the under surface being lighter, and the throat marked with dark longitudinal streaks. Known to the natives of Mozambique by the name of *toque*, this species appears to feed chiefly on beetles, grasshoppers, and ants.



ARMED AGAMA ($\frac{2}{3}$ nat. size).

Spinose Agama. Very different in general appearance to the last species is the spinose agama (*A. colonorum*) of West Africa, which is a rather large form, and said to be the most common reptile met with on the Gold Coast. It differs from the preceding species by the shields on the back being of uniform size and furnished with spines, as well as in the absence of a crest. The body is not much depressed, and the sides of the head near the ear, as well as of the neck, are ornamented with radiating groups of short spines, which are at least equal to two-thirds the diameter of the ear-opening. From an allied species (*A. rueppelli*) it may be distinguished by the scales on the back being very numerous, and considerably larger than those on the tail; the latter being strongly keeled and arranged in fairly distinct rings. Attaining a length of rather more the preceding members of the family are characterised by the absence of true pores on this part of the body or on the thighs. In a second group such pores are, however, present in both, or in one or other of these situations; and we select as our first example thereof the remarkable frilled lizard (*Chlamydosaurus kingi*) of Australia—the solitary representative of its genus. This extraordinary-looking creature, which attains a length of nearly 32 inches, about 11 of which are taken up by the tail, is at once recognised by the curious frill-like membranous expansion surrounding the throat and extending upwards to the sides of the nape. The frill, which is much more developed in the adult than in the young, has a serrated margin, and is covered with scales of larger size than those on the back; it irresistibly reminds one of the frills with which our ancestors were wont to adorn their throats, and communicates an altogether strange appearance to its owner. In form, the body of this lizard is slightly compressed, and although the scales of the back are strongly keeled there is no distinct crest in this region. The aperture of the ear is exposed, and the tail is either round or slightly compressed, the latter condition occurring in the adult male. The general colour of the upper-parts is pale brown, which may be either uniform or mottled with dark brown, or blackish mingled with yellow.

The frilled lizard is an inhabitant of Queensland and Northern and North-Western Australia, as well as some of the islands of Torres Straits; its fossil remains occurring in the superficial deposits of the first-named district. Recent observations show that it inhabits sandy districts, where it walks, with a swinging gait, on its hind-legs, after the manner of the extinct iguanodon. When frightened, it sits down on its hind-quarters, raises its fore-quarters and head as high as possible, strikes its body with its tail, and shows its teeth at the intruder. Although the creature is perfectly harmless, this attitude has been known to frighten people who have seen it for the first time; and it probably has the same effect on other enemies. The frill which, when fully extended, forms a shield concealing the body, limbs, and tail, is moved by certain special muscles, and is supported by rods of cartilage.

Sail-Tailed Lizard.

Nearly allied to the preceding is the sail-tailed lizard (*Lophurus amboinensis*), which is likewise the sole member of its genus, and takes its name from the presence of a tall sail-like crest on the upper surface of the tail of the adult, which is supported by a great lengthening of the spines of the vertebræ of that region. The body is markedly compressed, the back has a low crest, and the throat has both longitudinal puckerings and a transverse fold in the skin, while the aperture of the ear is exposed. In form, the head is short and thick, the compressed tail is long and powerful, and the legs and feet are also strong, the toes of the latter being covered inferiorly with small granular scales, and at the sides, especially externally, with a fringe of large united scales, which is one of the distinctive features of the genus. The covering of the upper-parts is in the form of small quadrangular scales, which are keeled on the head and back. The dentition comprises six small conical teeth in the front of the jaws, four long tusks, and thirteen cheek-teeth. On the thighs there is a row of pores. Attaining a length of over a yard, the sail-tailed lizard is of a general olive-brown colour, becoming greenish on the head and neck, and spotted and marbled with black; while an oblique fold in the skin on the front of the shoulder is deep black.

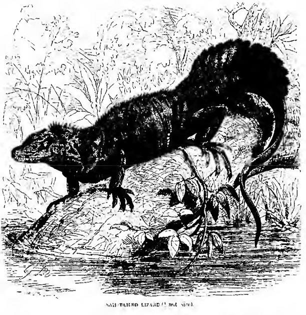
than 15 inches, this species is noticeable for its brilliant coloration in the living state, although the hues rapidly fade away after death. When alive, the head is flame-red, the throat spotted with yellow, and the body and limbs a deep steel-blue, while along the middle of the back there is generally a whitish line. The lower surface of the basal half of the tail is yellowish, the corresponding upper portion steely blue, as is the tip, while the remainder is red. Very old specimens have, however, both surfaces of the base of the tail blue, the remainder of the upper surface, except a small blue tip, being red. Females are at all ages much more soberly coloured. In some spots these agamas are found in swarms, being very fond of climbing up the mud-walls and mat-roofs of the native huts, at times basking motionless in the sun and at others running rapidly about in search of insects. When approached by a human being they raise and depress their heads in a series of nods, which increase in rapidity as the intruder draws near, till, finally, the creatures lose courage, and disappear, with the speed of lightning, into some crack or cranny. So brilliant do these gorgeously-coloured lizards appear, when basking in the midday rays of an African sun, that the observer is fain to believe he is gazing on some splendid insect rather than a reptile.

Rough Tailed Agama. Belonging to a group of the genus distinguished from the one containing the species described above by the absence of enlargement of the occipital scale of the head, the rough-tailed agama (*A. stellio*), depicted in the illustration on p. 105, is interesting as being one of the two members of the genus whose range extends into South-Eastern Europe. Whereas, however, the other members of the group have the tail more or less ringed, the rough-tailed agama, together with the second European species (*A. caucasica*) and a third (*A. microlepis*), are peculiar in that the tail is divided into distinct segments, each composed of a pair of rings of scales. Growing to nearly a foot in length, the species under consideration is distinguished by its stout body and the moderate degree of depression of the head, the cheeks of the male being somewhat swollen. The colour of the upper-parts is olive, spotted with black, and generally with a series of large yellow or olive spots down the middle of the back; the throat of the male having fine bluish grey net-like markings. Occurring in Europe, in Turkey, and certain islands of the Ægean Sea, the rough-tailed lizard is distributed over the whole of Asia Minor, Syria, Northern Arabia, and Egypt, being much more common in the latter regions than it is in Europe. To the Arabs it is known by the name of *hardun*; and it is commonly tamed and kept in captivity by the itinerant snake-charmers of Egypt. As shy and agile in its movements as its congeners, it feeds largely on flies and butterflies, which are captured with remarkable address and agility.

Before taking leave of this extensive genus, it may be mentioned that there is a third group, agreeing with the last in the small size of the occipital scale of the head, but distinguished by the absence of rings on the tail; the agile agama (*A. agilis*) of Persia being a well-known example. The genus *Phrynocephalus* of South-Eastern Europe and Central Asia comprises rather more than a dozen lizards nearly allied to *Agama*, but easily distinguished by the concealed aperture of the ear.

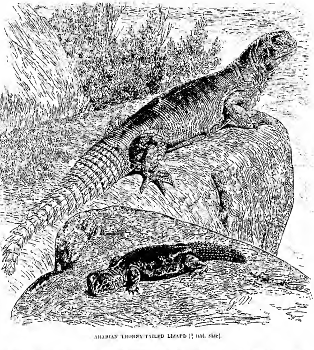
Australian Frilled Lizard. Although the swollen callous scales in front of the vent in the males of the agamas have some resemblance to them, the whole of

Originally brought to Europe from Amboyna, this curious lizard is an inhabitant of the Philippines, Java, Celebes, and the Moluccas; it is arboreal in its habits, and is generally found in wood or scrub in the neighbourhood of water. Its food consists of seeds, leaves, flowers, and berries, as well as worms, myriapods, and other creatures found in damp situations. If frightened, this lizard immediately dives into the water, and endeavours to conceal itself among the stones at the bottom where, however, it may be readily captured with a net, or even with the hand, as it makes not the slightest attempt at defence. Its eggs are laid in the sand of the river-banks. By the natives the creature is hunted for the sake of its flesh, which is white and well flavoured, and consequently much appreciated.



SAIL-TAILED LIZARD (1/[illegible] nat. size).

Thorny-Tailed Lizards. Quite a different type of tail to that of the last is presented by the thorny-tailed lizards, of which there are seven species, inhabiting arid tracts in Northern Africa and South-Western Asia. From the whole of the foregoing members of the present family, these lizards are sharply distinguished by the circumstance that the front teeth, instead of being small and conical, are large, and in the adult united together into one or two broad cutting-teeth, separated from those of the cheek-series by a gap; while externally they are easily recognised by their short tails covered with well-defined rings of spiny scales. The head is remarkably short and rounded; the body, as in most terrestrial members



ARABIAN THORNY-TAILED LIZARD (⅓ nat. size).

of the family, is much depressed; and there is no crest along the back. There are no folds or pouches on the neck, but pores are present both in front of the vent and on the thighs, and the aperture of the ear is exposed. The Arabian thorny-tail, or dabb, as it is termed by the Arabs (*Uromastix spinipes*), is one of the best known members of the genus, and inhabits Egypt, Crete, and Arabia. It belongs to a group characterised by the rings of spiny scales on the upper surface of the tail being in juxtaposition; while, in common with two other species, it is specially distinguished by the circumstance that two or more transverse rows of scales on the lower surface of the tail correspond with one on its upper aspect. The Arabian species, which attains a length of about 18 inches, differs from its two nearest allies in the minute size of the scales covering the body, coupled with the presence of a few scattered somewhat larger tubercular scales on the flanks. Its colour is either sandy grey, or greenish above, which may be either uniform or clouded with brown. The ornate thorny-tail (*U. ornatus*), of Egypt and Syria, differs from the other three members of the first group in that the scales of the tail form complete rings, those on the lower surface being as long as those on the upper.

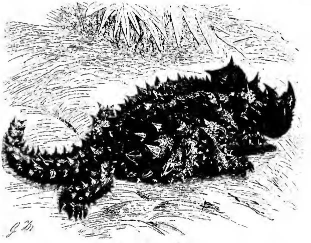
With the exception of one species (*U. microlepis*) inhabiting Persia, the members of the first group are confined to Africa, Arabia, and Syria, whereas the three representatives of the second group are exclusively Asiatic, one (*U. loricatus*) being from Persia, the second (*U. asmussi*) common to Persia and Baluchistan, while the third (*U. hardwickei*) is an inhabitant of Baluchistan and Northern India. In the whole of these three Asiatic species the rings of spiny scales on the upper surface of the tail are separated from one another by rows of smaller smooth scales. In the Indian thorny-tail the spines on the tail are small, with the lateral ones the largest; there are no enlarged tubercular scales on the back; and the front surface of the thigh is marked by a large black spot. In size this species is much inferior to its Arabian congener, not exceeding some 11 inches in length. Its colour is either uniform sandy above, or the same spotted or mottled with a darker, and whitish beneath, with the aforesaid dark mark on the thigh.

Habits. Conforming in their sombre coloration to the desert regions they frequent, the thorny-tailed lizards are entirely vegetable-feeders, and live in burrows, resembling those of the smaller foxes, which are excavated by themselves. These burrows, which may be as much as 4 feet in length, sometimes turn almost at right angles to their original course, at a depth of a foot or so from the surface. Generally living solitary or in pairs, these lizards are met with abundantly in parts of Eastern Persia and the Punjab, and when approached at once make for their holes. If they succeed in getting their fore-limbs within the aperture of their burrows, it is impossible to pull them out, for, as the writer knows by experience, they will rather suffer their tails to be pulled from their bodies than let go their hold. They are generally somewhat heavy and deliberate in the movements, turning their heads from side to side while walking, but are capable of running with tolerable speed. In the cold season, at anyrate, they never leave their burrows till the sun is well up; and while in Persia and India they are commonly found on half-desert gravelly plains scattered over with low bush, the Arabian species is often met with in the clefts of rocks, whence it issues forth to bask on the smooth slabs or boulders. According to Brehm, as many as a dozen of these lizards may occasionally be seen on a single slab of rock. All the species appear to be timid and gentle in their disposition, rarely, if ever, attempting to bite when captured. Their food comprises leaves and flowers, dried fruits, and the seeds of grass, as well as grass itself; but although in the wild state they seem never to touch animal food, in captivity the Indian species will greedily devour meal-worms. According to Arab reports, the dabb never by any chance drinks, even when water is at hand, and this statement has been confirmed by modern observers. By the Arabs these lizards are frequently tamed and kept in captivity; and their flesh, which resembles that of young chicken, is much relished by them as an article of food. Nothing appears to be known as to their breeding-habits. All the species thrive well in captivity in Europe. It is not improbable, according to Canon Tristram, that the reptile mentioned in Leviticus under the name of tortoise, is really the dabb.

East African Thorny-Tailed Lizards. Two nearly allied lizards from East Africa—namely, *Aporoscelis princeps* from Zanzibar and Somaliland, and *A. batilliferus* from Somaliland,—while resembling the members of the preceding genus in general external characters, differ in the absence of true pores either on the under surface of the body or on the thighs, and are consequently referred to a distinct genus. Both appear to be rare, and are of comparatively small size, the first-named measuring only about 7½ inches in length.

Moloch Lizard Even more strange and uncouth in appearance than the frilled lizard, is another Australian species commonly known as the moloch (*Moloch horridus*) but termed by the settlers the spiny lizard or thorny devil. This the last remaining representative of the agamoids, differs from all the other members of the family in being covered with large conical spines, and in the conformation of its mouth and teeth. In all the forms described above the mouth is large and the teeth of both jaws are erect, but in the moloch the mouth is very small, and the cheek-teeth of the upper jaw are placed horizontally, with their summits directed inwardly. About 8 inches in total length, this extraordinary lizard has a small head, with an extremely short snout, on the summit of which are pierced the nostrils; it has a much depressed body, a short and rounded tail and thick, powerful limbs armed with strong claws. On each side of the head immediately above the small eye is a large horn curving outwards and backwards, while there is a smaller conical spine above the nostril, a second behind the horn over the eye, a third and larger one in front of each ear, as well as one on each side of the occiput. Between these spines the upper surface of the head is protected by small granular tubercles; while among the spines on the upper surface of the body, limbs, and tail, are similar granules intermingled with polygonal scales of which the edges are in apposition. On the back the spines form ten or more longitudinal series, of which the outermost are the largest. The lower surface of the body has a covering of rough, and slightly overlapping scales, among which are numerous rounded and keeled tubercles. In general colour the creature is yellowish, ornamented with symmetrical chestnut or reddish brown markings defined by darker borders.

Inhabiting Southern and Western Australia, and being not uncommon in several localities in the neighbourhood of Port Augusta, the moloch is found only in districts where the soil is dry and sandy. Occasionally two or three may be observed basking in company on the top of a sandhill; and it is the frequent habit of this lizard to bury itself in the sand to a small depth below the surface. Its small eye and general manner indicate pretty clearly that the moloch is diurnal in its habits, although it may possibly occasionally move about during the night. Although generally very slow in its movements, it has been known, when disturbed, to make for a neighbouring hole with considerable speed. In repose it generally rests with the head so raised as to be on the level of the back. Its chief food appears to be ants, although vegetable substances are sometimes eaten. The female deposits her eggs in the sand. To a certain degree the moloch is endued with the power of changing its colour to harmonise with its surroundings, such changes taking place very gradually although not unfrequently. The most general change is to a uniform sandy slate, or russet colour, when the ornamental markings almost completely disappear. In spite of its ferocious and somewhat forbidding appearance, the moloch is a perfectly harmless creature, its formidable-looking armour being never used for attack. In captivity it is dull and sluggish, undergoing fasts of a month's duration without any apparent inconvenience.



MOLOCH LIZARD (nat. size).

THE IGUANOID LIZARDS

Family *IGUANIDÆ*.

The extensive family of lizards, of which the well-known iguanas of South America and the West Indies are the typical representatives, may be regarded as occupying the same position in America as is filled by the agamoids in the warmer parts of the Old World. Whereas, however, the agamoids are exclusively denizens of the Eastern Hemisphere, the iguanoid lizards are not absolutely confined to the

western half of the globe, two genera occurring in Madagascar, and a third in the Fiji and Friendly Islands. Although, with these exceptions, the family is unknown in the Old World, the same perverseness which causes Anglo-Indians to speak of the Oriental crocodiles as alligators, leads to the monitors of the Old World being commonly termed iguanas, although few lizards are more unlike than the members of these two groups, both as regards external and internal characters. In their general structural features the iguanoids come very close to the agamoids. Thus in both groups the head is covered with numerous small shields; while the back is clothed with scales of different kinds, which are often arranged in oblique rows. Similarly, the eyes have round pupils and are furnished with well-developed lids, and the drum of the ear is frequently exposed. Both groups, again, have two pairs of limbs, which may be relatively longer or shorter in the different genera, but are each provided with five toes. The length of the tail is subject to a large amount of variation, although it generally exceeds that of the head and body. Moreover, the two families resemble one another in the form and structure of the tongue, which is thick, short, scarcely notched, and generally fixed to the floor of the mouth throughout its length. When, however, we come to contrast the teeth of iguanoids with those of agamoids, we find a striking difference which at once serves to draw a sharp line of distinction between the two families. As we have already seen in the latter group the teeth are attached to the very summits of the bones of the jaws (acrodont), and are commonly differentiated into front teeth, tusks, and cheek-teeth. In the iguanoids, on the other hand, the tall and cylindrical teeth are attached by their sides to the outer wall of the jaws in the so-called pleurodont manner; the whole series being generally more or less uniform in character, and without any large projecting tusks. In the typical iguanas the teeth have somewhat diamond-shaped compressed crowns with serrated edges: and it was from a superficial resemblance to this type of tooth that the teeth of the great dinosaurian reptile from the English Wealden received the name of *Iguanodon*. A few genera, again, have the teeth divided into three lobes, thus resembling a fleur-de-lis. Many species of the family are further characterised by having teeth on the pterygoid bones of the palate, while a single genus is one of the few lizards in which there are teeth on the palatine bones.

The iguanoids, which comprise about three hundred species, arranged in fifty genera, may be regarded as especially characteristic of South and Central America, although they extend into the warmer parts of the northern half of that continent, ranging in the west as far as British Columbia, and in the east to Arkansas and the Southern United States, while they are also represented in many of the American islands. Their occurrence in Madagascar (where, as in America, agamoids are wanting) has been already mentioned, and it is probable that this remarkable instance of discontinuous distribution may be explained by the occurrence of fossil remains of species of the family in the upper Eocene rocks of France, where agamoids seem likewise to have been wanting.

Very variable in external appearance, iguanoids present equal diversity in their modes of life, and it is not a little curious that, with the exception of the flying lizard, almost every group of the agamoids finds a parallel, both as regards structure and habits, in the present family; the two families being thus representative groups. There are, however, certain iguanoids, such as the **anolis** lizards and the sea-lizards which have no representatives in the preceding family. The majority of the iguanoids feed on insects, although some, like the true iguanas and the sea-lizards, subsist on a vegetable diet, while one genus is stated to be omnivorous. Only two genera are known to produce living young.

Anolis Lizards. In the forests, groves, and gardens of all the warmer regions of America live a number of beautiful lizards commonly known by the name of anolis, which is applied in the Antilles to some members of the group. The distinctive features of these lizards are the pyramidal form of the head, the moderately long neck, the presence of a broad and generally brilliantly-coloured appendage on the throat of the males, the slender body, which may be either com-

RED-THROATED ANOLIS (nat. size).

pressed, cylindrical, or slightly depressed, the relatively long hind-limbs, the large feet, in which the toes are of very unequal length and their middle joints expanded, with smooth transverse plates on the under surface, and the long curved and sharp claws, which are raised above the level of the expanded joints. The tail is long and hard, although not prehensile; the covering of very minute scales on the back and tail is not unfrequently elevated to form a crest; the cheek-teeth are characterised by their distinctly tricuspid crowns, and teeth are generally present on the pterygoid bones of the palate. Lastly, these lizards possess the power of changing their colour to even a greater extent than is the case with the chameleons. From among more than one hundred species belonging to the genus we select for illustration the red-throated anolis (*Anolis carolinensis*), which inhabits the South-Eastern United States and Cuba, and presents the following distinctive features. The head, which is long, triangular, and depressed, is nearly smooth in the young, but in the adult has well-marked frontal ridges, and some large rough shields on the crown; and the appendage on the throat of the males is relatively small. The body is not compressed, flat beneath, and not keeled above; the scales on its upper and lower surfaces being keeled and approaching an hexagonal form, with their edges either in apposition or slightly overlapping. The tail is cylindrical and tapering, with some slightly enlarged scales on its upper surface, and nearly equal to twice the length of the head and body. In the living animal the colour of the upper surface is brilliant metallic green, and that of the underparts silvery white; the appendage on the throat of the males, which is covered with white scales, is red; there is a large blue eye-like spot above the axil of the fore-limb; and the region of the tail is ornamented with black markings. In some specimens the green colour passes more or less distinctly into brownish or brown; and, when excited, the creature is able to change its general hue from greenish grey, through dark grey and brown of all shades, to the ordinary metallic green. In length this lizard varies from 5½ to nearly 9 inches, according to sex; fully two-thirds of these dimensions being taken up by the tail.

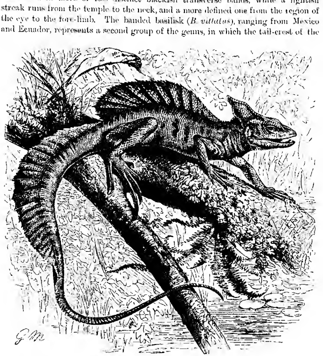
In Louisiana, Carolina, and Cuba, the red-throated anolis is one of the most common of lizards, and may be noticed in all suitable spots, such as woods and garden-hedges, as well as the exteriors, and sometimes also the interiors of dwelling-houses. Like their congeners, they are, however, to be met with most abundantly in the deep woods, and then so closely do they assimilate to their surroundings that their presence, when at rest on a bough, is generally only revealed by their brilliant eyes. In houses, these lizards exhibit but little fear of man, running about with the greatest unconcern in search of flies and other insects; and as, in addition to gnats, flies, butterflies, beetles, and spiders, they kill and eat wasps, scorpions, and other noxious creatures, their visits are encouraged. In motion throughout the day, they display extreme activity and speed, both when hunting among the foliage of trees or on the ground, pouncing upon their insect-prey like a cat upon a mouse. In the spring, during the breeding-season, the males display great jealousy of one another, so much so, indeed, that when two meet, a combat is certain to ensue, and is often continued till one of the combatants has lost its tail, which appears to be taken as an immediate sign of defeat. During these battles the appendage on the throat is inflated, and the changes of colour are more rapid than at any other time. With the advent of summer, these mutual animosities are, however, forgotten, and these lizards dwell together in perfect amity, sometimes collecting in large companies. The females of some of the species are stated to dig a hole for the reception of their few white eggs with their fore-paws, at the foot of a tree or in some moist spot near a wall, afterwards carefully covering them with soil to protect them from the sun's rays. The figured kind is, however, said to be very careless in regard to the place where its eggs are deposited; these being found either on bare sand or rocks, or even in rooms. The red-throated anolis, like most of its kindred, can be readily tamed, and makes a most charming pet, which can be without much difficulty transported to Europe. Writing of a pair which were at one time in his possession, Bell says that "I was in the habit of feeding them with flies and other insects, and having one day placed in the cage with them a very large garden-spider, one of the lizards darted at it, but seized it only by the leg. The spider instantly ran round and round the creature's mouth, weaving a very thick web round both jaws, and then gave it a very severe bite in the lip just as this species of spider usually does with any large insect it has taken. The lizard was greatly distressed, and I removed the spider and rubbed off the web, the confinement of which appeared to give it great annoyance; but in a few days it died, though previously in as perfect health as its companion. The lizard was evidently unused to the wiles of the British spider."

The crested anolis (*A. cuvieri*), belonging to a small group, with compressed and crested bodies and tails, is remarkable for the great extent to which the pouch on the throat can be inflated,—probably for the purpose of terrifying foes.

Allied Genera. Two lizards, respectively from Jamaica and Colombia, differ from all the species of true anolis in having prehensile tails, in consequence of which they are referred to a distinct genus—*Xiphocercus*. In a third genus, *Chamaeleolis*, the cheek-teeth have smooth and nearly spherical crowns.

Basilisks. The strange form of the members of the present genus of iguanoids probably suggested to the earlier naturalists the imposition of the name basilisk,—a term which, as all our readers are doubtless aware, originally denoted a fabulous snake-like reptile before whose deadly glance every living being save the cock perished. Be this as it may, the reptiles now known as basilisks are large, although perfectly harmless members of the present family, belonging to a group distinguished from the preceding one by the absence of dilatation of the toes, and the more or less marked backward prolongation of the hinder portion of the head. In the presence of a large crest on the upper surface of the tail the basilisks recall the sail-tailed lizards in the agamoid group, of which, indeed, they may be regarded as the representatives in the present family. As a genus, they are characterised by the head in the adult males being produced backwards into a large cartilaginous lobe; by the compressed form of the body and tail, which are covered with small overlapping scales; and by the presence of a crest on the back and tail in the males, such crests being always supported on the back by the prolonged spines of the vertebræ, and frequently also in the tail. Although there is a transverse fold on the throat, the pouch characterising the anolis lizards is wanting. The long limbs are covered with keeled scales; and the outer sides of the hind-toes have a much developed lobe of skin. The cheek-teeth have three-cusped crowns; and teeth are borne on the pterygoid bones. Internally, the basilisks form an exception to the members of this and the two preceding families in that the inner extremities of the collar-bones have a loop-like expansion, as in the geckos; while they differ from the anolis lizards in the absence of the false abdominal ribs so frequently present in this and the preceding families.

The basilisks are represented by four species from Tropical America, among which the figured helmeted basilisk (*Basiliscus americanus*) is the one most commonly known. It is the largest representative of the genus, attaining a length of about 31 inches, of which nearly three-quarters is taken up by the tail; and is one of two species characterised by the great height of the crest of the tail in the males, which is supported by prolongations of the spines of the vertebræ. Inhabiting Panama and Costa Rica, it is specially characterised by the undivided head-crest of the males; while the scales on the under surface of the body are smooth. The natural colour of the creature is probably green, although specimens preserved in spirit are olive-brown above, and dirty white beneath. The back is marked with more or less distinct blackish transverse bands, while a lightish streak runs from the temple to the neck, and a more defined one from the region of the eye to the fore-limb. The banded basilisk (*B. vittatus*), ranging from Mexico and Ecuador, represents a second group of the genus, in which the tail-crest of the males is low, and not supported by bony rays. In this species the scales of the under surface of the body are keeled, whereas in the allied *B. galeatus* they are smooth. In general appearance all the basilisks suggest the idea of lizards upon whose backs has been grafted a fish's fin. As regards their habits, all the members of the genus spend their time either on trees, or bushes, often basking in the sun on fallen stems, and seldom, if ever, venturing far from the neighbourhood of water. Most numerous in the vicinity of rivers, basilisks are, indeed, so common in Guatemala, that the collector has no difficulty in obtaining as many specimens as



HELMETED BASILISK (½ nat. size).

he may desire, although the rapidity of their movements is so great that some practice is required to effect their capture. Their food is entirely of a vegetable nature; and to gather this the basilisks are astir with the first rays of dawn, while during the heat of the day they prefer to rest among the most leafy boughs. At the slightest sound, they raise the head, inflate the throat, and elevate the crest; and as soon as the bright, yellow-irised eye detects the presence of a foe, the basilisks throw themselves instantaneously into the water above which they are usually reposing. In swimming, the head and neck are raised, the fore-limbs serve the part of propellers, while the crested tail acts as a rudder; hence the common name of "ferrymen" is applied to these lizards. At the end of April or beginning of May the female lays from twelve to eighteen eggs in some cranny at the foot of a tree, where they are left for the sun to hatch.

Ridge Headed Lizards

Nearly allied to the basilisks are the three species of ridge-headed lizards (*Corythophanes*) of Central America, characterised by the head being prolonged backwards into a bony, helmet-like projection, while the tail is devoid of a crest, although the neck and back are provided with a low appendage of this nature. On the throat there is both a pouch and a transverse fold. The most interesting of the three species is the one named *C. hernandezi*, in which the head is crowned with a helmet-like prolongation so like that of the chamæleon that the creature is commonly spoken of under that name by the Mexicans. Like the anolis lizards, these reptiles are in the constant habit of changing their somewhat sombre colours; and it has been observed in a captive specimen that whereas the patch on the pouch was white during the day, at night it assumed, like the other light parts of the body, a blackish hue.

Stilted Lizards

While agreeing with the basilisks in having the plates on the under surface of the toes distinctly keeled, there are a number of genera in the family distinguished by the absence of any backward prolongation of the crown of the head. Among these we select for mention the stilted lizards, specially characterised by the large size of the occipital shield of the head, the presence of a vacuity in the breast-bone, the small or moderate-sized scales of the tail, the long and highly curved toes, and the presence of tusk-like teeth in the jaws. There are but two representatives of the genus, both of which have a wide distribution in South America. The figured species (*Uraniscodon umbra*), which attains a length of about a foot, two-thirds of which are occupied by the long and cylindrical tail, has a short and frog-like head, raised into curved ridges over the eyes, with the muzzle very blunt, and the lower jaw longer than the upper. The skin of the neck is curiously puckered inferiorly, the folds forming a pair of pouches on the sides, although there is no pouch on the throat. In form, the body is at most but slightly compressed, with a low and slightly serrated crest running from the nape down to the back; and the uniform scales of the back are small and overlapping, and those on the top of the head enlarged. The long and bent toes are markedly compressed, and are furnished with short but strong claws. In coloration this species is one of the handsomest of its tribe. The general ground-colour of the upper-parts is reddish or purplish brown, ornamented with more or less distinctly defined blackish transverse bars; a broad black band traverses the fold in front of the shoulder, and may extend across the nape; while frequently in front of this band there is a large yellowish orange spot on each side of the neck. Below, the colour is brownish or yellowish, which may be either uniform or clouded with brown markings. An inhabitant of the great primeval forests of South America, the stilted lizard has the power of changing colour, and is consequently often designated a chamæleon. It generally associates in pairs, dwelling among trees, and its food appears to be entirely of a vegetable nature. When disturbed, it rushes suddenly up a high branch, where it stands with outstretched head and neck and widely open eyes, gazing steadily at the intruder. Should it be unable to escape otherwise, the creature raises its neck still higher, inflates the neck-pouches, and, with a sharp cry, springs boldly into the air.

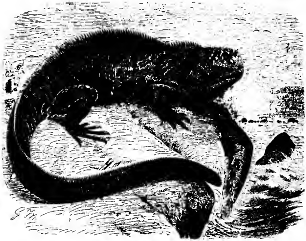
There are a very large number of genera, agreeing with those hitherto noticed in the absence of pores on the thighs, which the limits of our space prevent us from even mentioning. We accordingly pass on to the consideration of certain representatives of the second great group of the family, in which such pores are present.

STILTED LIZARD (nat. size).

The Sea-Lizard.

Both as regards their fauna and flora, the Galapagos Islands stand altogether apart from the rest of the world, the greater number of their animals and plants being absolutely peculiar,—it may be specifically, or it may be generically,—while herbivorous reptiles take the place occupied on the continents of the world by vegetable-eating mammals. In no case, however, is this faunistic peculiarity more marked than in the occurrence in such a limited area of two distinct genera of the present family, each represented by a single species. Remarkable alike for special features connected with their dentition, as well as for their large bodily size, these two lizards differ widely from the rest of the family. Whereas, however, the one is a land animal, the other is unique among the entire suborder to which it belongs in being a marine creature, subsisting on seaweeds.

Agreeing with the great majority of that section of the family characterised by the presence of pores on the thighs in the fourth hind-toe being longer than the third, the sea-lizard, together with the terrestrial species inhabiting the same islands, differs from all the rest in that the front teeth resemble those of the cheek-series in having three-cusped crowns, so that the entire set of teeth is uniform in character. From its terrestrial ally, the sea-lizard (*Amblyrhynchus cristatus*) is distinguished by its much compressed and crested tail, as well as by the presence of an incipient web between the toes. This lizard is the largest member of the family, and attains a total length of some 53 inches. It is characterised by the compressed form of the body and tail, and the extremely short and truncated head. A well-marked crest runs from the nape of the neck to the tip of the tail, and the whole build of the animal is stout and "chubby." The throat is devoid of a pouch, although it has a well-marked transverse fold, and the toes are laterally compressed. In the small and convex head the nostrils are situated near the end of the muzzle, the eye and aperture of the ear are alike small, and the upper surface is surmounted by a number of conical spine-like shields of relatively large size. The investing scales of the body are small, and although keeled on the back, are smooth below. In the stoutly-made limbs the toes are rather short, the third one in the hind-foot being

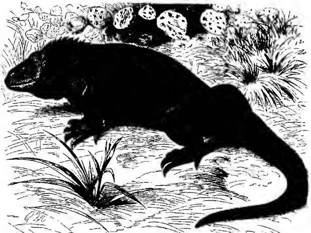


GALAPAGOS SEA-LIZARD (⅛ nat. size).

strongly serrated on its inner border of its basal joint. The compressed and crested tail is about equal to one and a half times the length of the head and body, and is covered with equal-sized keeled scales. In colour this lizard is black or blackish brown above, with the abdomen and the inner surfaces of the thighs not unfrequently of a dirty white. In the young state however, the upper-parts are brown with paler spots, and more or less distinctly marked dark crossbars on the back. In weight full-grown examples reach as much as 20 lbs.

The sea-lizard is extremely common on the rocky coasts of the various islands of the Galapagos Group, but is seldom found more than some ten yards from the shore. Of its habits Darwin writes that "this lizard swims with perfect ease and quickness by a serpentine movement of its body and flattened tail—the legs being motionless and closely collapsed on its sides. A seaman on board sank one, with a heavy weight attached to it, thinking thus to kill it directly; but when, an hour afterwards, he drew up the line, it was quite active. Their limbs and strong claws are admirably adapted for crawling over the rugged and fissured masses of lava, which everywhere form the coast. In such situations, a group of six or seven of these hideous reptiles may oftentimes be seen on the black rocks, a few feet above the surf, basking in the sun with outstretched legs." After mentioning that the stomachs of several examples that were examined contained finely minced seaweed, and also observing that the droves seen swimming out to sea were doubtless in search of food of this nature, the same author proceeds to state that, when frightened, these lizards absolutely refuse to enter the water. "Hence," he continues, "it is easy to drive these lizards down to any little point overhanging the sea, where they will sooner allow a person to catch hold of their tails than enter the water. They do not seem to have any notion of biting, but when much frightened they squirt a drop of fluid from each nostril. I threw one several times as far as I could into a deep pool left by the retiring tide, but it invariably returned in a direct line to the spot where I stood. It swam near the bottom, with a very graceful and rapid movement, and occasionally aided itself over the uneven ground with its feet. As soon as it arrived near the edge, but still being under water, it tried to conceal itself in the tufts of seaweed, or it entered some crevice. As soon as it thought the danger was past, it crawled out on the dry rocks, and shuffled away as quickly as it could. I several times caught the same lizard by driving it down to a point, and, though possessed of such perfect powers of diving and swimming, nothing would induce it to enter the water; and as often as I threw it in, it returned in the manner above described. Perhaps this singular piece of apparent stupidity may be accounted for by the circumstance that this reptile has no enemy whatever on shore, whereas at sea it must often fall a prey to the numerous sharks." Later observers have borne testimony to the extraordinary numbers in which the sea-lizards are to be met with in the Galapagos, and likewise as to their food consisting mainly of broad-leaved sea-leaves.

Galapagos Land-Lizards. Although originally included in the same genus as its aquatic cousin, there seems no doubt that the land-lizard of the Galapagos (*Conolophus subcristatus*) is entitled to stand as the representative of a distinct generic group; the nearly cylindrical tail and perfectly free toes being distinctive characters which cannot well be overlooked. Not reaching within some 11 inches of the dimensions attained by the last, this lizard is likewise a stoutly-built creature, with the rather small head slightly longer than broad, the body somewhat depressed, a slight spiny crest on the nape, continued as a low ridge on the back, and the scales of the latter small and keeled, while the slightly larger ones on the lower surface are smooth. Although devoid of a pouch, and with but a very slight transverse fold, the throat is strongly plicate longitudinally, and is covered with minute granules. The stout limbs terminate in very short toes, of which the third in the hind-foot is serrated on the inner margin of its basal joint. On the thigh the pores are arranged in a long series, and vary from seventeen to twenty-one in number. In length the tail scarcely exceeds the head and body, while in form it is slightly compressed, having a low ridge superiorly, and being covered with small keeled scales of uniform size. In general colour the creature is dark brown, with the head and under-parts lighter.



GALAPAGOS LAND-LIZARD (¼ nat. size).

These lizards are confined to the central islands of the Galapagos Group, such as Albemarle and James Islands, where they are found in great numbers in the low barren districts near the coasts, although also met with in the elevated damp regions of the interior. On James Island Darwin found them so numerous, that it was difficult to obtain a spot free from their burrows on which to pitch a tent. Attaining a weight of from 10 to 15 lbs. these lizards are lazy and sluggish in their movements, crawling slowly along with their bellies and tails dragging on the ground, and often stopping for a minute or two to doze with closed eyes, and the hind-limbs stretched out on the arid soil. According to Darwin's account, "they inhabit burrows, which they sometimes make between fragments of lava, but more generally on level patches of the soft sandstone-like tufa. The holes do not appear to be very deep, and they enter the ground at a small angle; so that when walking over these lizard-warrens, the soil is constantly giving way, much to the annoyance of the tired walker. This animal, when making its burrow, works alternately the opposite sides of its body. One front-leg for a short time scratches up the soil, and throws it towards the hind-foot, which is well placed so as to heave it beyond the mouth of the hole. That side of the body being tired, the other takes up the task, and so on alternately . . . . They feed by day, and do not wander far from their burrows; if frightened, they rush to them with a most awkward gait. Except when running downhill, they cannot move very fast, apparently from the lateral position of their legs. They are not at all timorous: when attentively watching anyone, they curl their tails, and, raising themselves on their front-legs, nod their heads vertically, with a quick movement, and try to look very fierce; but in reality they are not so at all; if one just stamps on the ground, down go their tails, and off they shuffle as quickly as they can." If worried with a stick, these lizards will bite it severely; and when two are held together on the ground, they will fight and bite till blood flows. "The individuals, and they are the greater number, which inhabit the lower country, can scarcely taste a drop of water throughout the year; but they consume much of the succulent cactus, the branches of which are occasionally broken off by the wind. I several times threw a piece to two or three of them when together; and it was amusing enough to see them trying to seize and carry it away in their mouths, like so many hungry dogs with a bone." They also eat the leaves of several trees, more especially of an acacia, to obtain which they ascend the low stunted trees, on the boughs of which they may often be observed quietly feeding. The females lay large eggs of an elongated form in their burrows; both these and the flesh of the lizards themselves being eaten by the inhabitants of the Galapagos.

True Iguanas

The true iguanas, of which there are two closely-allied species from Tropical America and the West Indies, differ from the two preceding genera in that the edges of the crowns of the cheek-teeth are serrated, while the front teeth are simply conical. The distinctive features of the iguanas are to be found in the long and much compressed body, the large four-sided head, covered above with enlarged scales, the short neck, powerful limbs, long-toed feet, and the much elongated tail, upon which the scales are uniform and keeled. The throat is furnished with a large non-dilatable appendage, in front of which is a crest of large compressed scales; and a continuous crest of long spines runs from the nape along the back, and is continued as a ridge on the tail. The scales on the back are small, equal, and keeled; the neck has some scattered large conical or bluntly-keeled tubercles, and there are also some large tubercular scales on the sides of the throat, more especially one below the aperture of the ear; while on the under-parts the scales are either smooth or slightly keeled. The pores on the thighs are numerous, and, in addition to those in the margins of the jaws, there are teeth on the pterygoid bones of the palate. The common iguana (*Iguana tuberculata*) attains a length of as much as a yard and a half, two-thirds of which are occupied by the tail. The general colour is green or greenish, becoming lighter on the under-parts; but the upper surface may be either uniform, or variegated with darker brownish bands, the flanks usually having light-edged vertical dark bars, while the tail has more or less distinct dark rings. There is frequently a whitish band in front of the arm, and some of the large tubercular scales on the sides of the throat and neck are often light coloured.

Both species of iguanas, of which there are several varieties, are essentially arboreal lizards, generally frequenting those regions of the forests where the trees overhang the water. Here they move with great agility, climbing or springing from bough to bough, while the harmony of their coloration to their surroundings renders them well-nigh invisible. Towards evening they not unfrequently descend to the ground to feed; but, when frightened, immediately rush to the topmost boughs of the trees, or plunge headlong into deep water. In the latter element they are, indeed, perfectly at home, and swim strongly and swiftly, with their limbs closely applied to their bodies, and impelled by their powerful tails. They are likewise expert divers, frequently remaining for a considerable time below the surface; their activity in the water being such that they are able to avoid all enemies save crocodiles and caimans. Their chief food consists of leaves, flowers and berries, although they will also eat insects; the numbers of small worms sometimes found in their stomachs having probably been swallowed accidentally. Generally seeking to escape at once from human beings, iguanas when unable to flee show fight, erecting their heads and assuming a fierce aspect, while at close quarters they bite savagely and administer severe blows with their powerful tails. The female deposits from eight to seventeen eggs in a hole dug in sandy soil, but as several individuals will not unfrequently lay together, as many as ten dozen eggs may be found in a single nest. In spite of their somewhat repulsive appearance, iguanas are hunted for the sake of their flesh, which is white in colour and delicate in flavour, and is said to resemble the breast of a chicken. The eggs also, which consist almost entirely of yolk, are highly esteemed as articles of diet. Iguanas are generally captured by means of nooses, which are thrown over their heads as they repose on the branches. The much smaller horned iguana (*Metopoceros cornutus*), of San Domingo, constitutes a separate genus, distinguished by the presence of an inflatable pouch on the throat.

Ring-Tailed Iguana

The West-Indian ring-tailed iguana (*Cyclura carinata*) is selected to represent a group of genera distinguished from the foregoing by the crowns of the cheek-teeth being three-cusped or simply conical. While four of these genera—among which is the Fijian iguana (*Brachylophus fasciatus*)—are characterised by the shortness of the row of pores on the thigh, the present species is one of those in which they form a long series; and it is further characterised by the presence of a serrated crest down the back and tail, and also of a pouch and slight transverse fold on the throat. The head is large, swollen below the ears, and furnished with enlarged scales on the snout; while the body and tail are compressed, the body being covered with small scales. The species derives its name from the rings of keeled scales which form regular segments on the sides of the tail; each segment being composed of from three to five series of

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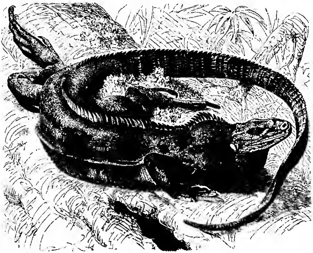
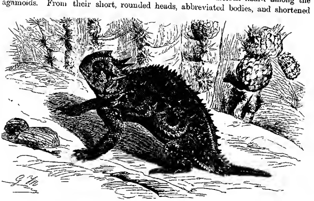
small scales, and a single series of larger and somewhat spinous ones. The toes are compressed, and covered below with keeled plates. In total length this iguana reaches about 48 inches; and its general colour is green or dark olive, speckled with darker and lighter, and frequently marked with blackish transverse bands. The ring-tailed iguana is a somewhat local species, occurring most abundantly in Jamaica, on the limestone mountains in the neighbourhood of Kingston Harbour and Goat Island, but also met with on the low grounds lying between the coast ranges and the higher mountains of the interior, where hollow trees occur. Shy and retiring in their habits, the creatures live in pairs, and display no great partiality for water, although, on occasion, they can swim as well as the true iguanas. They feed mainly or entirely on grass, and when disturbed in grazing, these reptiles rush back to the trees with extraordinary speed, sometimes taking great leaps like a frog, although their movements are generally deliberate and slow. If unable to escape, they show fight in much the same way as the true iguanas. The breeding-habits of this species do not appear to be known, although the females of the allied black iguana (*Ctenosaura acanthura*) of California are in the habit of laying in company, like the true iguanas. The ring-tailed iguana exhales a peculiarly disagreeable smell, which is stated to be so objectionable as to cause even the ants to forsake a room into which one of these creatures is brought. For this reason its flesh is uneatable, although that of the black iguana is highly esteemed.



RING-TAILED IGUANA (¼ nat. size).

Extinct Iguanas. We have not hitherto mentioned that the vertebræ of the iguanoid lizards differ from those of the agamoids and most other members of the suborder in being furnished with additional articular facets like those of snakes. Vertebræ of this peculiar type occur in the upper Eocene rocks of England and the Continent, and have been provisionally assigned to the typical genus *Iguana*, although it is more likely that they indicate an extinct genus. Somewhat similar vertebræ from the corresponding strata of the United States have been described under the name of *Iguanavus*.

Horned Lizards. The last and at the same time the most peculiar members of the present family are the horned lizards of North America and Mexico, which may be regarded as the representatives of the moloch lizard among the agamoids. From their short, rounded heads, abbreviated bodies, and shortened tails, coupled with a general batrachian appearance, these lizards are commonly termed toads in America, the popular name of the figured species (*Phrynosoma cornutum*) being the Californian toad. Strange, not to say ugly, in appearance, these lizards are at once distinguished from all their allies by the presence of several bony spines projecting from the back of the shortened head, and of tubercles or spines scattered among the ordinary scales of the body. In form, the body is broad and depressed, without any crest down the back; and the tail is very thick at the base, and never longer than the body. The limbs are rather long, with pores on the thighs, and keeled plates on the lower surfaces of the toes. From most other members of the family these lizards are further distinguished by the absence of teeth on the palate. Of the twelve species of the genus the best known is the common horned toad, herewith figured, which has the tail longer than the head, distinct spines on the back, and the drum of the ear naked. Its general appearance is even more than superficially toad-like, the head being as



HORNED LIZARD (⅔ nat. size).

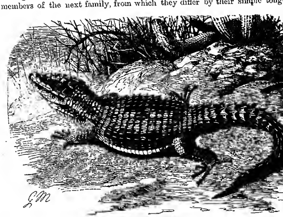
broad as long, and the body remarkable for its extreme plumpness. Measuring a little over 5 inches in length, this species is rather handsomely coloured. Above, the ground-colour is greyish or brownish, with a more or less well-marked light stripe down the back, and dark brown spots at the bases of the larger spines; while there are likewise markings of the same colour on the nape and head. Beneath, the hue is yellowish, with or without a few small brown spots. In two species of the genus (e.g. *P. taurus*) the tail does not exceed the head in length. The common species is found locally in sandy districts both on the plains and mountains, and is in some places abundant, although from its coloration frequently escaping notice. In spite of its somewhat formidable appearance, it is a harmless creature, not attempting to bite even when captured. Lacking the protrusive tongue of the chameleon, and being debarred by its clumsy form from running fast, the horned lizard is unable to capture the swifter insects, and consequently preys upon sand-haunting beetles, whose speed is inferior to its own; such prey being generally captured in the evening, and the creature lying passive on the sand during the day. Some species of horned lizards are remarkable as being the only members of the family, save one other genus, which produce living young; the number of young being in some instances as many as twenty-four. Always small feeders, these lizards are capable of undergoing long fasts with impunity; and as they are habituated to a dry atmosphere, and probably never drink, they may be sent packed in wadding long distances by post.

The most remarkable peculiarity connected with these lizards is their habit of ejecting jets of blood from the eyes, apparently as a means of defence. The following letter from Mr. V. Bailey, written from California, in 1891, describes the phenomenon as first observed by him: "I caught a horned toad to-day that very much surprised Dr Fisher and myself by squirting blood from its eyes. It was on smooth ground, and not in brush or weeds. I caught it with my hand, and just got my fingers on its tail as it ran. On taking it in my hand, a little jet of blood spurted from one eye, a distance of fifteen inches, and spattered on my shoulder. Turning it over to examine the eye, another stream spurted from the other eye. This he did four or five times from both eyes, until my hands, clothes, and gun were sprinkled over with fine drops of bright red blood. I put it in a bag, and carried it to camp, where, about four hours later, I showed it to Dr Fisher, when it spurted three more streams from its eyes." The phenomenon has been subsequently observed in other specimens.

THE GIRDLED LIZARDS.

Family *ZONURIDÆ*.

Omitting mention of a family represented only by one genus (*Xenosaurus*) and one species from Mexico, the next group for consideration is that of the girdled lizards, from Tropical and South Africa, and Madagascar, of which there are four genera. These lizards, which may be either snake-like in form, or provided with four fully-developed limbs, differ from all those hitherto described, with the exception of certain geckos, in having the temporal fossæ of the skull roofed over with bone; while they are further characterised by a fold covered with small scales running along the sides of the body and marking off the upper from the under-parts. The tongue is simple, with its anterior moiety not extensile, and its tip either rounded, or but slightly notched; while there are well-developed eyelids, and the drum of the ear is exposed. The back is either clothed with large shield-like, and mostly keeled scales, arranged in well-marked transverse zones, or, more rarely, with granules; the head having large, regular shields. As regards their teeth, these lizards conform to the pleurodont type, each tooth having its base widely open. Resembling in many respects the Iguanoids, from which they are distinguished by the ossifications in the skull, these lizards also approach the members of the next family, from which they differ by their simple tongues, the hollow bases of the teeth, and the structure of the bony plates underlying the scales, when such are present. In the South African snake-like genus (*Chamæsaura*), the fore-limbs are wanting, and the hind-pair rudimental, while the tail is of extraordinary length. All the members of the family appear to be carnivorous.



CAPE GIRDLE-TAILED LIZARD (nat. size.)

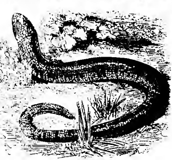
Girdle-Tailed Lizard. We take as our special example of this small family one of the members of the South African girdle-tailed lizards (*Zonurus*), a genus represented by seven species. These lizards differ from the other three genera in having the scales of the back underlain by bony plates of simple structure; and, resembling in appearance the rough-tailed lizard among the agamoids, they have a flattened triangular head, and a tail of moderate length. On the upper surface the neck and back are covered with large quadrangular shield-like scales, while beneath there are large flat shields; the limbs bearing keeled overlapping shields, and the tail being protected with whorls of spinous scales. The teeth are small, and the rounded tongue is scarcely notched. The figured species (*Z. cordylus*), which attains a length of rather less than 8 inches, generally has the back and tail of a dirty orange colour, the head and feet of a lighter yellow, and the under-parts white; although there are considerable variations from this normal coloration. All the members of the genus inhabit rocky districts, and prefer those where there are ledges, upon which they run in search of food or warmth. They are excellent climbers, and far from easy to catch, often leaving their tails with their would-be captors.

THE SNAKE-LIKE LIZARDS.

Family *ANGUIDÆ.*

Nearly allied to the preceding family is a small group of lizards of variable bodily form, typified by the common English blind-worm. Rigid in their bodies, and having large symmetrical bony shields on the top of their heads, these lizards resemble the girdle-lizards in the presence of bony plates beneath the overlapping scales, and also in that the temporal fossæ of the skull are roofed over with bone. They differ, however, in that the bony plates beneath the scales are permeated by a series of radiating or irregularly arranged canals; and also in the conformation of the tongue. The latter is composed of two distinct portions, namely, a thick basal half, covered with villose papillæ, and a smaller thin terminal moiety coated with scale-like papillæ, which is extensile, and capable of partial withdrawal into a sheath formed by a transverse fold at the front of the basal half. As regards their dentition, some forms have tubercular or conical teeth attached to the sides of the walls of the jaws in the typical pleurodont manner; but in the blind-worms the teeth are long, curved, loosely attached fangs, very like those of serpents. Instead of hollowing out the bases of the old teeth, as in the preceding family, the new ones grow up beneath them; and there may or may not be teeth on the bones of the palate. Some of the members of the family agree with the preceding in having a longitudinal fold along the sides of the body, while in others it is absent; and there is a similar variation in external form, some genera having fully developed five-toed limbs, while in others all external traces of these appendages have disappeared. In regard to the covering of the head, it should specially be noticed that there is a large occipital shield at its hinder extremity. All the species differ from the majority of lizards in changing their skin in a single piece, like most snakes. With the exception of some species of the American genus *Gerrhonotus*, which ascend low bushes, all these lizards live on the ground; and the whole of them are carnivorous, the larger species preying on reptiles and other vertebrates, and the smaller kinds on insects, spiders, slugs, and worms. While the blind-worms produce living young, the others lay eggs. Containing seven genera and some forty-five species, this family is most numerously represented in Central America and the West Indies, a few species occurring in North and South America, two in Europe, and one in the Himalaya and Burma; all the forms with functional limbs being American. From limitations of space, our notice of the family will be confined to two of the snake-like genera.

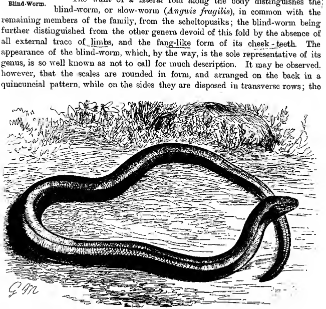
Scheltopusiks. The typical representative of this genus of snake-like lizards (*Ophisaurus apus*) was first discovered by Pallas in the wooded valleys of the steppes bordering the Volga, where it is known, in common with true snakes, by the name of scheltopusik, a term which may be conveniently applied to all the members. The species was subsequently discovered in other parts of Russia, as well as in Hungary, Istria, Dalmatia, Greece, Asia Minor, Syria, Persia, Transcaucasia, Transylvania, and Turkestan, while it is replaced in Morocco by a more brilliantly coloured variety. Four other species are also known, which extend the range of the genus to North-Eastern India, Burma, and North America. Agreeing with the American four-limbed genus *Gerrhonotus* in the presence of a fold along the sides of the body, and the more or less conical teeth, the scheltopusiks are distinguished by their moderately elongated snake-like form, and the absence of functional limbs; the European species alone having the hinder-pair represented by minute rudiments on the sides of the vent. These creatures are covered with squared scales, arranged in straight longitudinal and transverse series; and they are furnished with teeth on the pterygoids and in certain cases on some of the other bones of the palate. The European species, which, in addition to rudiments of hind-limbs, is distinguished by an aperture to the ear, attains a length of rather more than a yard, of which about two-thirds are occupied by the tail. The arrangement of the shields on the head is very much the same as in the blind-worm; and the general colour is brown, becoming lighter on the lower surface. The young are, however, olive-grey, with wavy dark brown crossbands on the back, and bars on the sides of the head. Dwelling among the dense underwood of thickly-wooded valleys, the scheltopusik harmonises so closely in colour with its surroundings, that it can only with difficulty be detected as it glides away among the dead leaves and sticks at the approach of a footstep. Although as free from venom as ordinary lizards, it is frequently mistaken for a snake, and then meets the fate which so often, under similar circumstances, befalls the blind-worm. Preying largely upon mice and voles, and not even hesitating to attack and kill the deadly viper, the scheltopusik is, however, a fierce and active creature, gliding swiftly and suddenly upon its victims among the moss and leaves of the woods. It also subsists largely upon snails; and is further reported to eat the eggs and young of birds. Its eggs are laid under thick bushes and leaves. The scheltopusik is believed to be a long-lived animal, the natives of the countries it inhabits stating that its full period of existence is from forty to sixty years. Fossil scheltopusiks occur in



COMMON SCHELTOPUSIK.

the Miocene deposits of Germany, some of which belong to an extinct genus (*Propseudopus*).

Blind-Worm. The want of a lateral fold along the body distinguishes the blind-worm, or slow-worm (*Anguis fragilis*), in common with the remaining members of the family, from the scheltopusiks; the blind-worm being further distinguished from the other genera devoid of this fold by the absence of all external trace of limbs, and the fang-like form of its cheek-teeth. The appearance of the blind-worm, which, by the way, is the sole representative of its genus, is so well known as not to call for much description. It may be observed, however, that the scales are rounded in form, and arranged on the back in a quincuncial pattern, while on the sides they are disposed in transverse rows; the ears are usually covered with integument; and the palate is toothless. Attaining a length of from 10 to 12, or even 14, inches, of which at least half is occupied by the tail, the blind-worm is of almost equal thickness throughout, although tapering slightly at the tail. The head is short and small; the eyes, although minute, are bright and piercing; and the tongue is but slightly notched. In the immature state the upper-parts are silvery, with a dark line down the middle of the back, while the sides and under-parts are blackish. The markings, however, often disappear in the adult, or may be replaced by dark dots, the upper surface becoming at the same time brown or bronzy. The range of the species includes Europe, Western Asia, and Algeria.



THE BLIND WORM (⅔ nat. size).

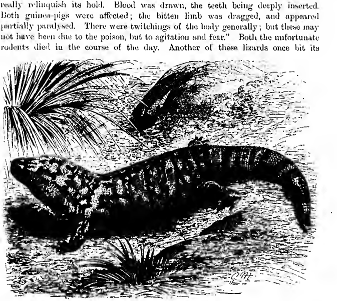
Gentle and inoffensive in its habits, and rarely attempting to bite even when rudely handled, the blind-worm is commonly regarded as one of the most noxious of reptiles. When captured, it usually contracts its muscles so forcibly as to become perfectly rigid, in which state it easily breaks if bent or struck, thus giving origin to its Latin name. Generally frequenting woods, heaths, and commons, the blind-worm is one of the hardiest of British reptiles, making its appearance in the spring at an earlier date than any other kind. According to Bell, "it retires in the autumn under masses of decayed wood or leaves, or into soft, dry soil, where it is covered with heath or brushwood, and penetrates to a considerable depth in such situations by means of its smooth, rounded muzzle and polished body." It feeds chiefly upon slugs, supplemented by various insects and worms. In June or July the female produces from seven to twelve or thirteen living young, which are active almost immediately after birth, and soon learn to feed by themselves. Like other viviparous reptiles, the female is much given to basking in the sun during the period of pregnancy, in order that its heat may aid in developing the eggs contained in her body.

THE POISONOUS LIZARDS.

Family *HELODERMATIDÆ.*

Two conspicuously coloured lizards, ranging from the isthmus of Tehuantepec in Central America as far north as New Mexico and Arizona, stand alone in the suborder in being poisonous, their bite, in certain cases at least, being sufficiently severe to produce very serious symptoms even on human beings, while smaller animals are soon killed thereby. These two species are the Mexican poisonous lizard (*Heloderma horridum*) of Western Mexico, and the Arizona poisonous lizard (*H. suspectum*) from New Mexico and Arizona, the former being known in its native country by the name of silatica. Nearly allied to the blind-worm, which they resemble in the general structure of their tongue and teeth, although distinguished by certain peculiarities in the conformation of the skull, and by the upper surface being covered with small granular tubercles, externally they are characterised by the depressed head, the plump, rounded body, the tolerably long cylindrical tail, the rather short limbs, in which the third and fourth toes are longer than the others, the exposed drum of the ear, and the transverse arrangement of the rows of tubercles on the upper surface. The curved and fang-like teeth are but loosely attached to the jaws, and have grooves in front and behind for the transmission of the poison; while there are also teeth on the palate. Beneath, the body and tail are covered with squared scales. In length, the figured species measures rather less than 20 inches, while the other is somewhat larger. The former has a yellowish or orange ground-colour, marked with a dark network on the head and body, and with blackish rings on the tail. Among the reddish sand, intermixed with dark pebbles, in which these lizards delight to nestle, this coloration, coupled with the granular nature of the skin, appears to be protective.

Inhabiting dry regions from the western side of the Cordillera to the Pacific, and apparently never entering water, the poisonous lizards are nocturnal in their habits, lying during the day hidden among the vegetation in a listless state, and issuing forth at evening. Their movements are at all times deliberate; and as these lizards are most commonly met with in the wet season, being but seldom seen during the dry months from November to June, it is probable that they are torpid during part of the latter period. Their food comprises insects, worms, myriapods, and small frogs, as well as the eggs of iguanas. Regarding the effects of their bite, Sir J. Fayrer writes that he once saw two guinea-pigs bitten by one of these lizards "The bites were viciously inflicted, and the lizard did not really relinquish its hold. Blood was drawn, the teeth being deeply inserted. Both guinea-pigs were affected; the bitten limb was dragged, and appeared partially paralysed. There were twitchings of the body generally; but these may not have been due to the poison, but to agitation and fear." Both the unfortunate rodents died in the course of the day. Another of these lizards once bit its owner, who was incautiously handling it, with very severe effects, which did not, however, prove fatal. The poison is secreted in special glands situated near the roots of the teeth.



ARIZONA POISONOUS LIZARD (¼ nat. size).

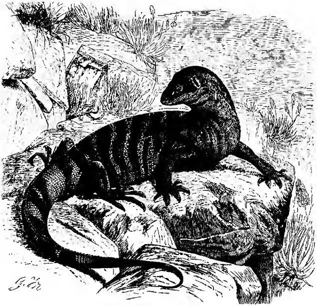
THE MONITORS.

Family *VARANIDÆ*.

No better instance of the essential difference in the distribution of lizards as compared with tortoises is afforded than by those lizards commonly known as monitors. The tortoises of Australia, as we have already seen, belong to a different suborder from those of India, while there are no genera common to Australia and Africa. The monitors, all of which are included in the single genus *Varanus*, are, however, common to the three countries named, while one species actually ranges from India to Australia. That this widespread generic distribution is not a feature of the present epoch is proved by the occurrence of fossil monitors in both the two latter countries; whereas we have no evidence that they possessed genera of tortoises in common. Before proceeding further, it is well to mention that the Egyptian representative of the group is known to the natives by the name of *ouaran*, which appears to be the Arabic term for lizards in general. Transliterated as *waran*, this word has been confused with the German *warnen*, to warn, whence these reptiles have been termed *warn-eidechsen*, or warning lizards; this, again, having been translated into *monitors*—a name which, however erroneous in origin, is too well established to be superseded.

The monitors are distinguished from all the lizards hitherto described by the long and deeply-forked tongue, which is capable of being protruded far in front of the lips, and is furnished at the base with a sheath, into which it can be withdrawn, as in snakes. Including the largest members of the suborder, monitors are further characterised by the long body, the broad, uncrested back, the well-developed, five-toed limbs, and the long tail, which is very frequently markedly compressed. The head is covered with small polygonal scales; the eyelids are well developed; the opening of the ear is distinct; and the head is covered with small scales. In the skull we may notice alike the absence of a bony roof over the temporal fossæ, and of teeth on the palate; while it is further remarkable for the union of the two nasal bones into a single ossification. The teeth are large and pointed, with expanded bases fixed to the sides of the jaws. On the back the scales are rounded and bordered by rings of minute granules, so that they do not overlap; while in the under surface we find the squared scales arranged in cross rows. Pores are absent both on the under surface of the thigh and in front of the vent. A peculiarity of the group is the presence of an imperfect midriff, found elsewhere among reptiles alone in the crocodiles. Monitors inhabit Africa, Southern Asia, Oceania, Papua, and Australia, and are represented by nearly thirty living species, the largest of which attains a length a little short of 7 feet. A fossil species from Northern India was, however, probably 12 feet long, while one from Australia could not have fallen much, if at all, short of 30 feet. The group is an isolated one, without near relationship to any other family.

The genus may be divided into four distinct sections, the first of which is represented solely by the desert-monitor (*V. griseus*) of North-Western Africa and South-Western Asia, extending from Arabia and the Caspian to North-Western India. This species differs from all the rest in that the nostrils are in the form of oblique slits, while the tail, except sometimes near its tip, is cylindrical. Attaining a length of 4 feet 2 inches, and inhabiting the deserts of North-Western India and thence westwards through Southern Asia to the Caspian and North Africa, it takes its name from its greyish yellow colour, which may be relieved by brown crossbars on the back and tail and streaks of the same hue along the sides of the neck; the young always having yellow spots and dark bars. In accordance with its sombre coloration, this species is an inhabitant of sandy deserts. A far handsomer lizard than the last is the Cape monitor (*V. albigularis*) of Southern and South-Eastern Africa, where it is commonly known to the Boers as the "adder." It is the first representative of the second group of the genus, in which, while the nostrils are in the form of oblique slits, the tail is compressed and keeled. Belonging to a subgroup characterised by the smooth scales of the abdomen, it is further distinguished by the absence of large (supraocular) scales above the eyes, by the nostril being three times as far from the snout as from the eye, and by the small size of the scales. It is slightly inferior in size to the last, and has the upper-parts greyish brown, banded and spotted with yellow, and the under-parts yellowish. It generally frequents cliffs, or low rocky hills, in the interstices of which it delights to hide, coming out to bask on the flat surfaces. Gray's monitor (*V. grayi*) is an example of a second subgroup in which the abdominal scales are keeled. In the third great group, of which we take as our first example the water-monitor (*V. salvator*), represented in the coloured Plate, round or oval nostrils are accompanied by a compressed tail. In the species in question there is a series of transversely elongated scales above the eyes, the oval nostril is situated as far from the eye as from the tip of the snout, there are more than eighty transverse rows of scales be-



CAPE MONITOR (⅙ nat. size).

tween the fold on the throat and the groin and the scales on the nape are not larger than those of the back. This fine species, which ranges from India through the Malayan region and China to Australia, attains a length of nearly 7 feet, and is the largest of the genus. In colour it is dark brown or blackish above, with yellow rings; the snout being generally lighter, with transverse black bars and a dark band, bordered by a yellow one, running backwards from the eye; the under surface being uniformly yellow. The water-monitor frequents marshy localities, being often found on trees overhanging rivers, and taking readily to the water, either fresh or salt. The last species that we notice is the well-known Nile monitor (*V. niloticus*), whose range extends all over Africa except a portion of the north-western regions. Belonging to the same great group as the last it represents a second subgroup distinguished by the equality in the size of the scales above the eyes; while it is distinguished from its allies by the nostril being rather nearer the tip of the eye than the snout. In size it is somewhat larger than the desert monitor. The colour of the adult is brownish or greenish grey, with darker reticulate markings, and more or less distinct yellowish eye-like spots on the back and limbs; while beneath it is yellowish, crossed by some dark bands. This species is likewise found in the neighbourhood of water, generally building itself a nest among the bushes on the banks, especially of those streams that dry up in the hot season. The Papuan monitor (*V. prasinus*) of New Guinea and the islands of Torres Straits may be cited as an example of the fourth group of the genus, in which, while the nostrils are round, the tail is nearly or quite cylindrical.

Habits.

As will be gathered from the foregoing, the monitors present considerable diversity of habitat, although the majority prefer the neighbourhood of water. The Papuan species is, however, believed to be arboreal. All are carnivorous in their diet, feeding on frogs, snakes, the smaller mammals and birds, as well as the eggs of both birds and reptiles, especially crocodiles. Their movements are extremely rapid, both on land and in water; and many a sportsman in his first day's snipe-shooting in the rice-fields around Calcutta has been startled by the sudden rush of the common Indian species (*V. bengalensis*) as it darts among the herbage close to his feet. Those species in which the tail is the most compressed are the best swimmers; this appendage serving as a powerful propeller in the water, and being also used as a weapon of offence on land. In order to enable them to remain under water for some time, the nostrils are expanded into large cavities within the snout; and when the apertures are closed these pouches serve as reservoirs of air. Writing of the great water-monitor, Cantor says that it is "very numerous in hilly and marshy localities of the Malayan Peninsula. It is commonly during the day observed in the branches of trees overhanging rivers, preying upon birds and their eggs and smaller lizards, and when disturbed it throws itself from a considerable height into the water. It will courageously defend itself with teeth and claws and by strokes of the tail. The lowest castes of Hindus capture these lizards commonly by digging them out of their burrows on the banks of rivers, for the sake of their flesh." Professor V. Ball gives the following account of a meeting with a lizard of the same species in the Nicobars.—"As I did not care to shoot him though I wanted to capture him I threw stones at him, whereupon he hissed and lashed his tail in a manner that

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might prove alarming to anyone not knowing the harmless nature of the beast. As I was pressing him into a corner, he made a rush into the waves, but returned, apparently not liking the surf. Just as I thought he could not escape, he made a sudden dart into the water, dived through the surf, and disappeared."

From observations made on specimens in captivity, it appears that these lizards eat eggs by taking them in their mouths, raising their heads, and then breaking the shells, so that the contents are allowed to run down their throats. Although but little is ascertained regarding their breeding-habits, monitors are known to lay white, soft-shelled eggs, which are deposited sometimes in the nests of white ants. As many as twenty-four eggs, of a couple of inches in length, have been taken from the body of a single female. By the Burmese these eggs are much relished as articles of food, and command a higher price in the market than hens' eggs.

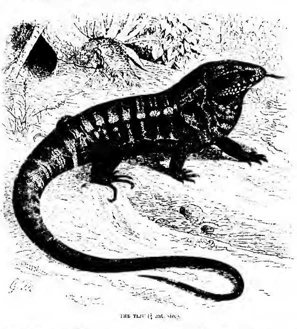
THE GREAVED LIZARDS.

Family *TEIIDÆ*.

In America the place of the true lizards of the Old World is taken by a nearly allied group which may be termed the greaved lizards, some of which rival the smaller monitors in size. In common with the remaining members of the suborder, these lizards are distinguished from all the foregoing by their tongues, which are slit at the tip and frequently shaped like an arrow-head, being either covered with overlapping scale-like papillæ, or marked by oblique folds. In all, the head is covered with large symmetrical shields, very different from the small scales of the monitors. They further differ by the collar-bones being dilated, and often loop-shaped at their inner extremities.

The greaved lizards are specially characterised by the absence of a bony roof to the temporal fossæ of the skull, and by the shields of the head being completely free from the underlying bones; while there are no bony plates on the body. On the body and tail the scales are arranged in transverse rows. The teeth, although very variable, differ from those of the true lizards of the Old World in not being hollow at the base; the replacing teeth being developed in small sockets at the roots of those in use. In some cases these teeth, which may be either pointed or of a flattened crushing type, are placed near the summits of the jaws, and in others somewhat on the side, so that the dentition is intermediate between the typical acrodont and pleurodont modifications; the front teeth are always conical. On the palate teeth are but seldom present, and, if developed, are small. The long tongue, which is frequently retractile within a sheath, is generally covered with overlapping scales; the drum of the ear is exposed; and the eyes are generally furnished with lids. The majority of the forms resemble the true lizards in general appearance, although in some the number of toes is reduced to four. In others however, the limbs take the form of mere stumps, while the hind pair may be wanting, in which case there is a near approach to the amphisbænas.

The greaved lizards comprise over a hundred species, arranged in thirty-five genera, which are distributed over the warmer parts of America, although most numerous in the equatorial regions. [illegible] in their habitat, some frequent dry, sandy plains, others dwell among the herbage of meadows, while others prefer woods and a few are partially or wholly subterranean; these latter either taking possession of some empty hole, or digging one for themselves. In their general mode of life they resemble the monitors and true lizards, although some are more like the amphisbænas. They are generally swift and active in their movements; and the larger kinds are thoroughly carnivorous, subsisting not only on insects, worms, slugs and snails, but likewise hunting such of the smaller vertebrates as they are able to overcome. Most species deposit their eggs in the hollow stems, or among the roots of trees. A few of the larger species are hunted for the sake of their flesh, which is stated to be tender and well-flavoured.



THE TEJU (¼ nat. size)

The Teju. One of the largest and best known representatives of the family is the lizard variously termed the teju, teguexin, or jacuaru (*Tupinambis teguexin*) which ranges over a large portion of South America and the West Indies, and belongs to a genus comprising three species. These lizards together with eggs. The female lays from fifty to sixty hard-shelled eggs about the size of those of a pigeon, generally placed in the hillocks of white ants.

The dracæna (*Dracæna guianensis*), of the Guianas and Amazonia, is a somewhat smaller lizard, distinguished by its compressed and doubly-keeled tail, the intermixture of keeled tubercles among the scales of the back, and the extremely broad crowns of the cheek-teeth.

The Ameivas.

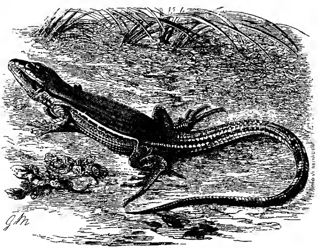
Our second figured representative of the family is the Surinam ameiva (*Ameiva surinamensis*), belonging to a genus of nearly twenty species distributed over Central and South America, where they take the place occupied by the true lizards in the Old World. They are distinguished by their round, keelless tails, the presence of less than twenty rows of large smooth scales on the under surface of the body, and the compressed two- or three-cusped cheek-teeth. The tongue can be withdrawn into a sheath. The figured species, which is found over South America as far as Nicaragua, attains a length of from 15 to 20 inches, and is very variable in coloration. The young are olive-brown, with darker markings or white dots, and a black, white-edged band running along the side of the body and extending on to the tail; these bands generally disappearing with age, although sometimes retained in the females. In the adult the upper surface is usually greenish, with some black and a few white spots; while the under-parts are greenish white, spotted with black on the sides. Ameivas are generally found in dry districts—more especially near the coasts, and in their general habits are not very different from the teju, usually living in holes, among old wood, or the herbage of gardens.

THE AMPHISBÆNAS.

Family *AMPHISBÆNIDÆ.*

Among the most remarkable of all lizards are those whose typical representatives have the power of moving equally well either backwards or forwards, from whence they derive the name by which the group is now commonly designated. Very nearly related to the preceding family, through those members of the latter with aborted limbs, the amphisbænas are distinguished by the simple and degraded characters of the skull, in which all the arches have been lost, and the two premaxillary bones are fused into one. All are adapted to a purely subterranean existence, and have long, worm-like bodies, devoid, except in one species, of any external trace of limbs; while even the bones of the shoulder and pelvis are more or less rudimental. The eyes are concealed beneath the skin; the mouth is small, and frequently inferior in position; and the ear is completely wanting. Although the head is covered with large symmetrical shields, the skin of the body is divided into squared segments forming regular rings, like those of worms; from which character the group is sometimes spoken of as the ringed lizards. In all the tail is short. The large teeth are few in number, and fixed either to the inner or upper edges of the jaws.

The amphisbænas, which are arranged in eleven genera, including between sixty and seventy species, are most numerously represented in America south of may be recognised by the tail being round at the root and slightly compressed near the middle, the double fold of skin on the neck, the uniform scales of the back, the rather small squared shields of the under surface of the body, which are arranged in more than twenty rows, the want of teeth on the palate, the compressed tricuspid cheek-teeth of the young, and the long tongue, which is of nearly equal width throughout, and sheathed at the base. In old individuals the crowns of the cheek-teeth become obtuse. The teju, which attains a length of about a yard, is a bulky and strikingly coloured lizard. Above, the ground-colour is olive, upon which are markings and bands of black, and more or less distinct rows of lighter spots; while the under surface is yellowish, with interrupted black bars; the lines of division between the shields of the head being black.


SURINAM AMEIVA (½ nat. size).

Ranging from Guiana to Uruguay, the teju is said by Bates to be very common in the forests of the Amazon, where it may be observed in numbers during the midday stillness scampering, apparently in sport, over the dead leaves; while in other districts it haunts sugar-plantations. Although frequently found in the neighbourhood of water, it apparently never enters it; and generally dwells in wide-mouthed holes situated beneath the roots of trees. Shy and retiring to a degree in inhabited districts, when driven into a corner it shows fight, hissing at and striking with its muscular tail the dogs employed in its pursuit. When sitting, the head is generally raised, while the forked tongue is in constant motion. Its diet comprises such living creatures as it can capture, together with eggs. The female lays from fifty to sixty hard-shelled eggs about the size of those of a pigeon, generally placed in the hillocks of white ants.

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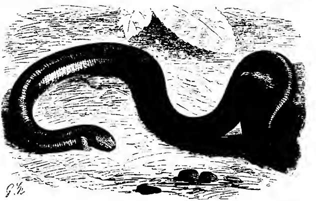
The amphisbænas, which are arranged in eleven genera, including between sixty and seventy species, are most numerously represented in America south of the Tropic of Cancer, although also occurring in the West Indies, while Africa possesses over twenty species, and four are found in the Mediterranean area. Of their habits, Mr. Boulenger observes that all the members of this family are burrowers, and may live in ants' nests. They bore narrow galleries in the earth, in which they are able to progress backwards as well as forwards. On the ground they progress in a straight line by slight vertical undulations, not by lateral movements, as in other limbless reptiles; and the tail of many species appears to be more or less prehensile. The food of these lizards consists of small insects and worms. As regards their breeding-habits, it is only known that one species lays eggs, which are deposited in ants' nests. The marked resemblance of these lizards to earth-worms is a most curious instance of the similarity produced in the external form of different groups of animals by adaptation to similar modes of life; the remarkable feature in this case being the occurrence of this resemblance in creatures so widely sundered from one another, as are worms and amphisbænas. Fossil members of the family have been discovered in the Tertiary rocks of North America.



HANDED AMPHISBÆNA (nat. size).

Handed Amphisbæna. The one member of the family which exhibits evidence of its relationship to less specialised lizards in the retention of rudimentary fore-limbs is the handed amphisbæna (*Chirotes caniculatus*) of Mexico and California; this being one of the two species found on the continent of America to the north of the Tropic of Cancer. This creature, which attains a length of about 7 inches, and is of a brownish flesh-colour, is distinguished by the presence of a pair of small depressed fore-limbs, placed close to the head, to which they are about equal in length; each of these being provided with four well-developed and clawed toes, of which the outermost is the shortest.

Typical Amphisbænas

The typical members of the family constitute a genus (***Amphisbæna***) common to Tropical America and Africa, and represented by nearly thirty species. Belonging, like the last genus, to the group in which the teeth are attached to the inner edges of the jaws, these limbless amphisbænas are specially characterised by the anterior body-rings not being enlarged, by the laterally placed nostrils being pierced in a special nasal shield, by the rounded or slightly compressed snout, the obtuse, cylindrical tail, and the presence of pores in front of the vent. The figured species (*A. fuliginosa*) is a well-known kind from Tropical America and the West Indies, deriving its name from its pied skin, and attaining a length of about 18 inches. Writing of the habits of a member of the genus, Bates observes that their "peculiar form, added to their habit of wriggling backwards as well as forwards, has given rise to the fable that they have two heads, one at each extremity. They are extremely sluggish in their motions, and live habitually in the subterranean chambers of the sauba ant; only coming out of their abodes occasionally in the night-time. The natives call the amphisbæna the *mai das saübas*, or mother of the saubas, and believe it to be poisonous, although it is perfectly harmless. It is one of the many curious animals which have become the subject of mythical stories with the natives. They say the ants treat it with great affection, and that if the snake be taken away from a nest the saübas will forsake the spot. I once took one quite whole out of the body of a young jararaca [a poisonous snake], whose body was so distended with its contents that the skin was stretched out to a film over the contained amphisbæna. I was, unfortunately, not able to ascertain the exact relation which subsists between these curious reptiles and the saüba ants. I believe, however, that they feed upon the saübas, for I once found the remains of ants in the stomach of one of them."

SPOTTED AMPHISBÆNA ([illegible] nat. size).

THE TRUE LIZARDS

Family *LACERTIDÆ*.

The true lizards constituting the typical representatives of the suborder, form a large family, with seventeen genera, distributed over Europe, Asia and Africa (exclusive of Madagascar), but most abundant in Africa, and comparatively rare in the Oriental countries. Taking the place in the Old World occupied in the New by the grooved lizards, these reptiles are readily distinguished from the latter by the temporal fossa of the skull being roofed over with bone (as shown in the figure of the skeleton on p. 108), and likewise by the shields of the head being firmly attached to the underlying bones, as well as by the union of the two premaxillary bones, the latter feature being common to this family and the amphisbænas. All of them have well-developed limbs, each furnished with five toes, the body plump, and separated by a well-marked neck from the head, the tail long and brittle, the drum of the ear exposed, and the eyelids distinct and generally freely mobile. The skin contains no bony plates: the scales of the back are either overlapping or in apposition, while those of the under surface are generally larger, and arranged in longitudinal and transverse rows. The teeth are always attached to the sides of the edges of the jaws (pleurodont) and differ from those of the grooved lizards in their hollow bases; those of the cheek-series having two- or three-cusped crowns. The flat and scaled tongue is of considerable length, and cleft both in front and behind, so as to assume the form of an arrow-head. As a rule, pores are present on the hinder surface of the thigh.

Out of about one hundred species of true lizards, two are found in the British Islands, where, with the exception of the blind-worm, they are the only representatives of the suborder; but many others inhabit Southern Europe. Lizards of this family are veritably creatures of the sun, delighting to bask in its rays on some warm sandy bank, wall, or rock, and retiring to their holes and crannies in cloudy or rainy weather. The more powerful and bright is the sun, the more active, indeed, do these reptiles become, since most of them are dull and listless in the mornings and evenings, and only wake to full activity in the midday glare. Over the greater part of Europe they begin to spend a large portion of their time in their holes, and with the commencement of October retire for their winter sleep, from which they do not awake till spring is well advanced. Comparatively rare in Northern Europe, in the south of the continent lizards are common enough to form an attractive feature in the landscape, their burnished metallic green and bronzy scales flashing in the sunlight on every wall, and in every road and path. The darting movements of these pretty reptiles, as they are in pursuit of the flies and other small insects which constitute their chief prey, are familiar to all. While the majority lay eggs, the viviparous lizard produces living young.

Pearly Lizard.

The pearly lizard (*Lacerta ocellata*) of Southern Europe, which is also represented by a variety in Algeria, may be taken as our first example of the typical genus *Lacerta*, of which there are over twenty species, inhabiting Europe, North and West Asia, Africa north of the Sahara, and the Atlantic islands. The members of this group, which may be collectively designated collared lizards, are distinguished by the following features. The body is cylindrical or slightly depressed; the head pyramidal, with upright sides; the neck not very well defined; and the tail cylindrical, tapering, and long. The throat is furnished with a well-marked collar of enlarged scales; the scales on the back are smaller than those on the tail, and are at most but slightly overlapping; while the shields of the under surface are squared, and slightly overlapping. The rounded or compressed toes have either smooth, tuberculated or indistinctly keeled pads on the lower surface, while the thighs have pores. In common with several other genera, the nostrils are placed close to the so-called labial scales, from which they are separated at most by a narrow rim; and if there be a transparent disc in the lower eyelid, it is smaller than the eye. Among the most beautifully coloured members of the suborder the pearly lizard, which attains a length of from 16 to 23 inches, claims a foremost place. Belonging to a large group of the genus, in which the edge of the throat-collar is strongly serrated, this species agrees with certain other members of the genus in its smooth tail, and in the scales on the sides of the body not being smaller than those on the back. As special characters of the species, it may be noted that the scales are smaller than in the allied forms; and that there are not less than seventy scales round the middle of the body, eight or ten of which belong to the under surface. The head is very large in the male, and characterised by the great width of its hindmost, or occipital, median shield. In colour, the upper parts are either green, with black dots or network, or blackish olive with yellowish netting; the sides are marked with a row of about a dozen eye-like blue spots; while the under surface is uniform greenish yellow. The olive-coloured young are, however, dotted all over with white, or pearly-blue, black-edged spots.

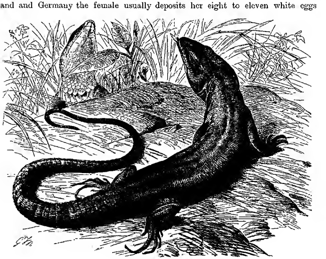
Common in Spain, and also occurring in the south of France and North-Western Italy, or wherever the olive grows, the pearly lizard is generally to be met with in the neighbourhood of hollow trees, frequently ascending some distance up their trunks, or even climbing among the branches. The males are somewhat quarrelsome, and the females lay from six to ten eggs, generally deposited in a hollow olive-tree.

Green Lizard.

Another well-known European species is the green lizard (*L. viridis*), attaining a length of about 12 inches in Germany, but in the more southern portions of its habitat measuring as much as 17 inches; fully two-thirds of this length being occupied by the long tail. Having not more than sixty-six scales round the middle of the body, this lizard is distinguished by the general presence of two small superimposed scales behind each nostril, the small size and triangular form of the occipital shield, and the arrangement of the abdominal scales in six longitudinal rows, the collar being serrated. Usually the nostrils are in contact with the front or rostral shield of the head; and in the female and young the foot is longer than the head. As regards colour, the males, which may be distinguished from the females by the larger and higher head, the thickened root of the tail, stouter hind-limbs, and generally superior size, are some shade of green-olive, passing below into yellow. Black dots, passing into large spots, generally adorn the upper surface, whereas the under-parts, save for a blue patch on the chin and throat, are uniform. The females, in which the blue on the throat is less constantly present, have a more brownish tinge, with the sides ornamented with black-bordered yellowish spots. The young are generally leather-brown in colour, with one or two yellow side-stripes. Both sexes vary, however, considerably according to age; and southern specimens are more brilliantly coloured than those from the north.

The green lizard is an inhabitant of the countries lying to the east and north of the Mediterranean, and thence extending eastwards to Persia. Very common in

Portugal and Spain, where it is represented by a variety, it extends in France as far north as Paris, but it is unknown in Sardinia. In place of resorting, like the pearly lizard, to trees, this species is usually found on the ground, more especially in districts where the subsoil is rocky, ranging from the sea-level to a height of some three thousand feet, and being equally at home on the plains or among the mountains, in stony or sandy districts, on bare rocks, or among thick bush. As rapid as lightning in its movements, it feeds chiefly upon large insects and their larvæ, together with slugs and worms; living in grassy districts almost entirely upon grasshoppers, and at times attacking smaller species of its own tribe. In Switzerland and Germany the female usually deposits her eight to eleven white eggs during June, these being hatched in the course of a month or so; and it is generally during the breeding-season that the blue on the throat is assumed by this sex.



GREEN LIZARDS (⅔ nat. size).

Sand-Lizard. The third European representative of the genus is the much smaller sand-, or hedge-lizard (*L. agilis*), which is a more northern form, ranging into the British Islands and Scandinavia. Usually not more than 8 inches in length, although occasionally measuring nearly 10, this lizard may be recognised by its short, thick, and blunt-snouted head, and by the tail being considerably less than twice the length of the head and body. Never having more than fifty-eight scales round the middle of the body, it is further distinguished by the rostral shield of the head being separated by a small interval from the nostrils, by the trapezoidal shape of the small occipital shield, by the absence of the row of small granules which occur between the shields of the eyelids (supraoculars) and eyebrows (supraciliaries) in the green and wall-lizards, and by the foot being not longer than the head. Although there is great variation in this respect, the general colour of the male is greenish, and that of the female grey or brown; the crown of the head, a streak down the back, and the tail being mostly brown, while the chin and under-parts are greenish or yellowish. The streak down the back, and in the females also the sides, are marked by rows of white spots, which are sometimes large and eye-like; and the under surface is marked with black. Some individuals, especially males, closely approach the green lizard in coloration.

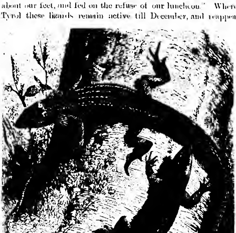
The range of the sand-lizard embraces North, Central, and Eastern Europe, and extends eastwards to Western Siberia and Asiatic Russia. In England it is generally found on sandy heaths, where it may often be seen running across the open paths with a speed less rapid than that of the more common viviparous species. It is more timid and less easily tamed than the green lizard, generally pining and refusing to feed in captivity. According to Bell, the female lays her eggs, to the number of twelve or fourteen, in hollows in the sand, which she excavates for the purpose, and having covered them carefully with sand, she leaves them to be hatched by the solar heat.

Viviparous Lizard. A still smaller, and at the same time a more slightly built species is the common English viviparous lizard (*L. vivipara*), which varies in length from 6 to just over 7 inches in length. It has larger scales than the last, which are not more than forty-five round the middle of the body, and the foot generally exceeds the head in length; granules being absent above the eyes. The absence of teeth on the palate is another feature in which this species differs from the sand-lizard. The colour of the adult is brown, yellowish, or reddish, ornamented with small dark and light spots, and often with a dark streak down the back, and another, edged with yellowish, on each side. In the male, the under surface is orange or vermilion, spotted with black, and in the female, pale orange or yellow, sparsely spotted with black, or uniform. The young are nearly black, and this hue occasionally persists. Unknown to the south of the Alps, the viviparous, or, as it is sometimes called, mountain-lizard, is spread over the greater part of North and Central Europe, and the whole of Northern Asia, as far as Amurland, ranging in the Alps to a height of nearly ten thousand feet. At this elevation it is, however, dormant for fully three-quarters of the year, being active for only two or three months. In Britain it extends to Scotland, and is one of the few reptiles found in Ireland. Generally similar in its habits to its allies, it is more fond of water, and is a good swimmer, usually frequenting heaths and banks. "Its movements," writes Bell, "are beautifully graceful as well as rapid; it comes out of its hiding-place during the warm parts of the day from the early spring till autumn has far advanced, basking in the sun, and turning its head with a sudden motion, if an insect comes within its view, and, darting like lightning upon its prey, it seizes it with its little sharp teeth, and speedily swallows it." Unlike its kin, this species produces living young, varying from three to six in number, which are active as soon as born, and remain in the company of their parent for some time.

Wall-Lizard. The last representative of the typical genus that we shall notice is the beautiful wall-lizard (*L. muralis*), of which a group is depicted in our coloured Plate. This southern species, which inhabits the countries bordering both sides of the Mediterranean, and extends eastwards into Persia, belongs to a group in which the edge of the collar on the neck is even or but slightly serrated, and the scales of the back are granular. Attaining in Germany a length of from 7 to 7½ inches, but reaching from 8 to 9½ inches in Italy, this species has a series of granules between the shields above the eyes, while the scales of the abdomen are arranged in six (rarely eight) rows, and those on the upper surface of the leg are larger than those on the back; and there is but a single (postnasal) scale behind each nostril. In colour the wall-lizard presents such an astonishing variation, that it is almost impossible to give any general description. In German examples the ground-colour of the back is, however, often brown or grey, with bronze-green reflections in sunlight, upon which are blackish streaks, marblings, and spots; while the flanks have a row of blue spots; and the under-parts vary from milk-white to copper-red, frequently variegated by spots or marblings. In Southern Europe these lizards may be seen basking on almost every wall, old building, or face of rock, where they delight all beholders with their activity and tameness. "Scarcely two," writes Leith-Adams, "are marked alike; the brightness and variety of their hues are most beautiful and attractive, and, like the chamaeleon, they change colour with the coruscations of sunshine, but, of

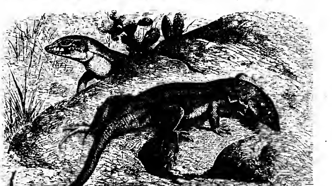
VIVIPAROUS LIZARD (nat. size.)

course not to the same extent. During an excursion to the islet of Filfla, on the southern coast of Malta, in the month of June, I was surprised to find that all the lizards on the rock were of a beautiful bronze-black, and so much tamer than their agile brethren on the mainland. Many individuals were so tame that they scrambled about our feet, and fed on the refuse of our luncheon." Whereas in the Southern Tyrol these lizards remain active till December, and reappear by the middle of February, in Germany their winter sleep is considerably longer. Like its congeners, this species has an exceedingly brittle tail; and it was observed some years that on a certain road in Madeira all the lizards belonging to a nearly allied species (*L. dugesi*) were without tails. The circumstance was explained by the spot being the favourite resort of the midshipmen landing from the ships visiting the island, who amused themselves by knocking off the lizards' tails.



ALGERIAN KEELED LIZARDS (⅔ nat. size).

Keeled Lizards. The members of the genus *Lacerta*, as we have seen, are characterised by the presence of a well-marked collar on the neck, by the scales of the back being smaller than those on the tail, and by the toes being without fringes on their sides, or keels on their soles. An allied genus—*Algiroides*—represented by three species from the eastern coast of the Adriatic, Greece, Sardinia, and Corsica,—differs by the strongly overlapping scales of the back being nearly as large as those of the tail. On the other hand, four species inhabiting South-Western Europe and the opposite coast of Africa constitute a third genus—*Psammodromus*—in which the collar is indistinct or wanting, the toes are not fringed, though generally more or less distinctly keeled inferiorly, while the overlapping scales of the back bear strong keels. Among these the Spanish keeled lizard, or sand-runner (*P. hispanicus*), retains a trace of a collar and has strongly keeled soles; whereas in the Algerian keeled lizard (*P. algirus*) the collar is



COMMON FRINGE-TOED LIZARDS (nat. size).

wanting, and the soles are at most but feebly keeled. The figured species, which inhabits not only North-Western Africa, but likewise Portugal, Spain, and the south of France, reaches nearly 10½ inches in length, and has a tail almost twice as long as the head and body. It is specially distinguished by the scales of the abdomen being of nearly equal width and arranged in six rows, as well as by the presence of from thirty to thirty-six scales round the middle of the body. In colour, this lizard is bronzy-green above, with one or two golden, dark-edged streaks along the side; the male being ornamented with a pale blue eye-like spot above the shoulder, sometimes followed by one or two behind, while the under-parts are whitish. Abundant in Algeria and the neighbourhood of Montpellier this lizard is found in the former region both in hedges and on limestone rocks, whereas in France it frequents hedges alone. Preferring dry, open, and warm districts, and thriving well in captivity, it presents nothing specially noteworthy as regards its habits.

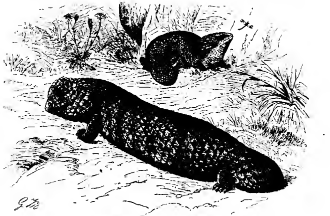
Fringe-Toed Lizards.

The fringe-toed lizards (*Acanthodactylus*), of which there are ten species ranging from Southern Spain and Portugal, and Northern Africa through South-Western Asia to the Punjab, differ from the preceding group by the toes being both fringed on the sides and keeled below; a more or less distinct collar occurring on the throat. On the head, the occipital shield is wanting, and the nostrils are pierced between two nasal and one labial shields. Pores are present on the thigh, and the tail is nearly cylindrical. The common fringe-toed lizard (*A. vulgaris*) is a species of from 4¼ to 4¾ inches in length, agreeing with most of its kindred in having the hinder scales of the back but little enlarged, and specially characterised by the strong keeling of the scales on the upper surface of the tail, and the slight pectination of the toes. It is represented by two varieties, one occurring in Spain and Portugal, and rarely in the south of France, characterised by the smooth or slightly keeled scales of the back, and an African form in which these scales are very strongly keeled and the coloration is brighter. The colour of the adult is greyish or brownish, with faint longitudinal series of light and dark spots and lines, and sometimes eye-like blue spots on the flanks; the young being longitudinally streaked with black and white, and having white spots on the limbs. All these lizards inhabit dry sandy districts, and are remarkably shy in their habits, seldom venturing forth from their retreats except when the sun is shining brightly.

The Skink Tribe

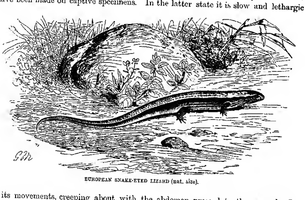
Family *SCINCIDÆ*.

The preceding family is connected with the one we have now to consider by a small group of five African genera constituting the family *Gerrhosauridæ*, which, while resembling the true lizards in having but a single premaxillary bone and the presence of pores on the thigh, agree with the skinks in possessing bony plates of peculiar structure beneath the scales. The skink tribe, taking their title from the lizard commonly known by that name, are a very numerous family, comprising upwards of twenty-five genera and nearly four hundred species, and presenting great variety of bodily form, some kinds being four-limbed, while others are more or less completely snake-like. Agreeing with the true lizards in the characters of the tongue and teeth, as well as in the roofing-over of the temporal fossæ by bone, the skinks differ in having two distinct premaxillary bones in the skull, in the presence of bony plates traversed by symmetrical tubules beneath the scales, and in the invariable absence of the pores which are generally present in the thighs of the *Lacertidæ*. The limbs, when present, are relatively short, and in some cases are reduced to two, and in others absent; the number of toes is very variable, even among the members of a single genus; the short and scaly tongue is free, and but slightly notched in front; and the drum of the ear is generally covered with scales. The eyes have round pupils, and well-developed and generally mobile lids, the lower one of which has a large transparent window. The teeth, which are attached to the sides of the jaws, may have either conical, bicuspid, or broad and spheroidal crowns (*Tiliqua*). The head is covered by large symmetrical shields, among which an unpaired occipital is generally wanting; and the overlapping scales of the body are generally subhexagonal in form and arranged in a quincuncial manner. Worldwide in distribution, the skink tribe are most numerously represented in Australia, Oceania, the Oriental region, and Africa, while very few occur in South America, and there are not many in North America and Europe. Although their habits are not fully known, it appears that, with the exception of two genera, they bring forth living young, varying from two to ten in number. The majority are terrestrial, a few only being able to climb, while none are aquatic. They sedulously avoid the neighbourhood of water, frequenting dry situations, and more especially those where the soil is sandy with an admixture of pebbles or fragments of rock. Moreover, they generally possess the faculty—rare among lizards—of burrowing in the ground with the dexterity, if not with the power, of moles. From this habit the group is sometimes spoken of as the burrowing lizards; and it may be remarked that their spindle-shaped bodies, covered with highly polished scales, their short legs, and frequently abbreviated tail, as well as the transparent window in the lower eyelid, are all features specially adapted for such a mode of life. From among the numerous genera, the limits of our space render it necessary to confine our remarks to four, which are selected as examples of very divergent types.



STUMP-TAILED LIZARDS (⅓ nat. size).

Stump-Tailed Lizard. Described as far back as the year 1699, the stump-tailed lizard (*Trachysaurus rugosus*), of Australia, is the sole representative of one of the most remarkable genera in the entire suborder. With a short, pyramidal depressed head of great width, a short but distinct neck, a long, thick, and flattened body, and a very wide and stumpy tail, the creature is clothed with an armour of rough, thick, brown scales, which give it very much the appearance of a living pine-cone. On the lower surface, the scales are smooth and much smaller. The small and stout limbs are widely separated, and terminate in five short toes, each provided with strong curved claws. In length this strange reptile measures about 14 inches, and its colour above is brown with spots or irregular bands of yellow, while beneath it is yellowish, with brown spots, marblings, or longitudinal and transverse streaks. The cheek-teeth have subconical crowns. Beyond the fact that it is a burrower, scarcely anything appears to be known of the habits of the stump-tailed lizard in a wild state, although many observations have been made on captive specimens. In the latter state it is slow and lethargic in its movements, creeping about with the abdomen pressed to the ground. Its chief food consists of worms and insects, although fruit and vegetables are occasionally eaten; and that it can endure long fasts is proved by an example which only ate two or three flies during the voyage from Australia.



EUROPEAN SNAKE-EYED LIZARD (nat. size).

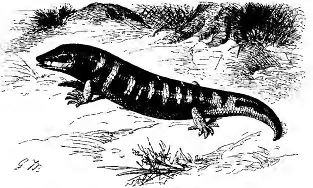
Snake Eyed Lizards.

Very different in appearance to the last is the lizard (*Ablepharus pannonicus*) represented in the accompanying illustration, which belongs to a genus containing a number of small species distributed over Australia, South-Western Asia, South-Eastern Europe, and Tropical and South America, one of which (*A. boutoni*) ranges irregularly over the hotter parts of both the Eastern and Western Hemispheres. These lizards differ from all their kin in having no movable eyelids, their place being taken by a transparent disc of skin stretched over the eye after the manner of snakes. In this genus the ear may be either open or concealed by scales; and while some of the species have well-developed limbs, in others they are more or less aborted, the number of toes being also highly variable. The figured species, which ranges in Europe from Hungary to

Greece, and is also spread over Asia Minor, Syria, and Northern Arabia, measures only 4 inches in length, of which fully half is occupied by the tail. Its general colour above is bronzy olive, becoming darker on the sides, and with a blackish light-edged streak passing through the eye along each side of the body; while the under-parts are greenish. The European species is found alike on slopes covered with short grass or in sandy spots, and does not appear to be a burrower. Feeding on small insects and worms, it does not generally venture forth from its lurking-places till four or five o'clock in the afternoon, and retires before night. In common with the other members of its genus, it differs from the majority of its family in laying eggs.

True Skinks

While both the genera above-mentioned belong to a group characterised by the palatine bones meeting in the middle of the palate, the true skinks indicate a second and smaller group in which those bones are separated from one another. Skinks are neatly made, somewhat short-tailed lizards, with short limbs provided with five toes serrated on their sides. The tail is conical, the head and snout wedge-shaped, the ear more or less concealed, while the nostrils are pierced between an upper and a lower nasal shield. Of the nine species of the genus, which range from North Africa through Arabia and Persia to Sind, the most familiar is the common skink (*Scincus officinalis*), of the Sahara and Red Sea littoral. This species, which attains a length of 8¼ inches, has smooth, shining, rounded scales of great breadth, and is of a yellowish or brownish colour above, with each scale marked by small brown and whitish spots and streaks, and the sides of the body often ornamented with dark transverse bands; the under-parts being uniformly whitish. Not uncommon in Egypt, and abundant in the Algerian and Tunisian Sahara, the common skink derives its specific name from having been extensively employed

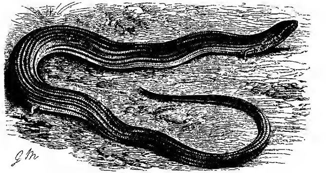


COMMON SKINK (⅘ nat. size).

in medicine as an infallible remedy for almost every disease under the sun; its reputation as a healing agent still surviving among the Arabs, by whom the flesh of the creature is used both as a drug and as an article of food. The exclusive haunts of the skink are sandy districts, where it generally moves in a slow and deliberate manner, and when frightened buries itself in the soil instead of attempting to seek safety in flight. Indeed, the celerity with which the reptile sinks into the sand is described as being little short of marvellous, suggesting the idea of its escaping into some hole already existing rather than of excavating a fresh burrow for itself, such a burrow not unfrequently extending to the depth of several feet. During the daytime the skink, if quietly approached, may be observed quietly reposing in the sun by the side of one of the small hillocks or ridges raised in the sand at the base of trees by the wind; and from such a state of idleness it is only roused by the approach of a beetle or a fly, upon which it darts with unerring aim. In spite of its strong teeth or claws, when captured, the skink never makes any attempts to defend itself, beyond struggling vigorously. Of its breeding-habits little or nothing definite appears to be known. According to Canon Tristram the flesh of a few well-broiled skinks forms a dish not to be despised even by a European palate.

Bronze Lizards Under the title of *Chalkis*, the ancient Greeks designated a remarkable snake-like lizard inhabiting Italy, Sardinia, and Sicily, as well as Algeria and Tunis, which was known to the Romans by the name of *Seps*, the latter being in allusion to the poisonous properties with which this perfectly harmless reptile was supposed to be endowed. The "seps" (*Chalcides tridactylus*) is the typical representative of a genus of some twelve species belonging to the present family, which exhibit a most interesting example of the gradual degradation of limbs, some species having five toes to each foot, while in others, as the figured example, the number of digits is reduced to three; and in one kind the limbs are represented merely by undivided rudiments. The bronze lizards, as the members of the genus may be collectively termed, belong to an assemblage of genera differing from all those already noticed in that the nostrils are pierced either in or close to the terminal rostral shield of the skull, instead of being more or less widely separated therefrom. In the case of the present genus the nostrils are situated in notches cut in the hinder border of the shield in question; while the body is greatly elongated, and the limbs are either short or rudimental. The figured kind is one of two species with three-toed limbs, and attains a length of 13½ inches, of which about half is occupied by the tail. In colour it is olive or bronzy above, and may be either uniform, or marked with an even number of darker and lighter longitudinal streaks. In the south of France, Spain, and Portugal it is replaced by the smaller striped bronze lizard (*C. lineatus*), in which the body is marked with nine or eleven longitudinal stripes. The range of the whole genus embraces Southern Europe, Northern Africa, and South-Western Asia, from Syria and Arabia to Sind.

The three-toed bronze lizard much resembles the blind-worm in general appearance and habits, frequenting damp places, where abundance of its favourite worms, snails, slugs, insects, and spiders are to be met with. Here it moves with a wriggling serpentine motion similar to that of the blind-worm, which it likewise resembles in producing living young and in retiring into a burrow for its winter sleep. When not feeding, the creature, like most of its kind, delights to bask on sandy spots in the full glare of the sun. The "seps" was believed to inflict death on cattle by biting them during the night, its bite filling their veins with corruption; and in consequence of this belief the unfortunate creature is still persecuted with the same hatred as is the blind-worm in some parts of England.



THREE-TOED BRONZE LIZARD (nat. size).

Other Families. The two remaining families (*Anelytropidæ* and *Dibamidæ*) are represented by worm-like burrowing lizards allied to the skinks (of which they may be regarded as degraded types), but with no bony plates beneath the scales, no external ear-openings, and eyes concealed beneath the skin. The former family is represented by three genera, of which two are African, and the third is from Mexico; while of the latter there is but a single genus, with one species from Papua, the Moluccas and Celebes, and a second from the Nicobars.

THE CHAMÆLEONS.

SUBORDER Rhiptoglossa.

With the skinks and their allies we took leave of the last of the reptiles which, in the zoological sense, are included under the title of lizards, and we now come to the second subordinal group, represented by those strange creatures known as chamæleons. From the lizards proper these reptiles are at once distinguished by their worm-like extensile tongues, which are club-shaped and viscous at the extremity, and are capable of being protruded with the rapidity of lightning to a distance of from four to six inches in front of the mouth. Hence the name of worm-tongued lizards has been suggested for the group. Internally, the chamæleons differ from all lizards provided with well-developed limbs in having no collar-bones (clavicles); while there are likewise certain distinctive features in connection with the skull, into the consideration of which it will be unnecessary to enter in this work. Another important feature by which these reptiles differ from lizards is the structure of the feet, in which the toes are divided into two opposing branches, thus forming grasping organs of great power. In the fore-foot the inner branch of the foot includes three, and the outer two toes, in the hind foot precisely the reverse arrangement obtains; and from this peculiar hand-like structure of the foot,—which by the way recalls the feet of the parrots and many Picarian birds,—the chamæleons have been spoken of as four-handed lizards. Yet another peculiarity in the structure of these reptiles is presented by the eye, which is in the form of a very large and prominent globe covered by a thick granular lid, in the centre of which is a minute perforation for the pupil. The deliberate way in which a chamæleon rolls round one of these extraordinary eyes until it has focused it on the fly about to be caught by the tongue is familiar to most of our readers.

The foregoing are the essential features by which the chamæleons are distinguished from the lizards proper; those remaining for mention not being such as would be regarded by zoologists as of subordinal importance. Among these may be noticed the triangular helmet-like form generally assumed by the hinder part of the head, which often has three longitudinal ridges, connected together posteriorly by a cross-ridge, all of which are ornamented with tubercles. The teeth, which are small, triangular, and compressed, are placed on the summits of the jaws in the acrodont fashion, none being present on the palate. The body is much compressed, and the neck short; the slender limbs are so much elongated as to raise the body high above the ground in a manner different from ordinary lizards; the tail is long and prehensile, thus acting as a fifth hand; and in place of scales, the head and body are covered with tubercles or shagreen-like granules. The larger species attain a length of some 15 inches, but the dwarf chamæleon of Madagascar (*Brookesia nanus*) is less than 2½ inches in length.

The chamæleons include close on fifty species, all of which are comprised in the single family *Chamæleontidæ*, and by far the greater majority in the typical genus *Chamæleon*. Indeed, of the two aberrant genera, *Brookesia* is represented by three species from Madagascar, while *Rhampholeon* comprises two tropical African kinds. The true home of the group is Africa and Madagascar, together with the neighbouring islands, each of these areas comprising nearly half of the known species. The common chamæleon (*C. vulgaris*) is, however, found on the African and Asiatic coasts of the Mediterranean, entering Europe in Andalusia; while a second species inhabits the Isle of Socotra, a third Southern Arabia, and a fourth India and Ceylon.

Habits. Evidently extremely specialised creatures, chamæleons stand altogether apart from the lizards, not only as regards their anatomical structure, but likewise in their power of moving one eye independently of the other, in the enormous extensibility and protrusive power of their tongues, and in their slow and deliberate movements. According, however, to those who have had the opportunity of observing them in their native haunts, chamæleons do not move quite so slowly as in confinement, where they take half a minute in determining which limb to move, or on which bough to replace it. Passing the whole of their lives in trees, like most of their Malagasy compatriots, the lemurs, chamæleons are chiefly found only in regions where foliage is abundant, and where the fall of rain or dew is sufficient to supply them with the amount of moisture they need. Consequently, they are most numerously represented in coast districts and islands. A few, however, frequent such parts of desert regions as come under the influence of the sea moisture, and support a more or less scanty vegetation. Needless to say, all the species live on insects, and more especially flies of various kinds, which are caught by the viscid secretion of the tip of the protrusile tongue.

Being utterly defenceless creatures, and having a large number of enemies, chamæleons depend entirely upon their resemblance to their environment for protection; and for this end they have the power of changing colour, although not, apparently, to such an extent as is the case with some lizards of the genus *Calotes*. At night they appear generally to be of a whitish yellow hue, but with the first dawn of day assume the dark green colour characteristic of most of the species, which exactly assimilates to the surrounding leaves, and continues to grow brighter and brighter with advancing day. When resting on a bough, or when captured in the hand, the colour changes, however, to brown; this change in the latter case taking place with exceeding rapidity, and the skin sometimes becoming nearly black, with the disappearance of all the bright marking. This change, according to Miss C. C. Hopley, is due to anger; the creature at the same time emitting a sound something between a hiss and the chirp or squeak of a very young bird and trying to bite its captor. "Meanwhile, it is all impatience to ascend, no matter where, so that it climbs upwards. Up, up, always up; it may be your dress, or whatever is near. It seems to think it can be safe only at the top of something. And yet they are not found invariably on the upper branches of their bush, though generally rather high. Released from the hand, its anger soon subsides, so does the dark hue, and the creature assumes the tint of the surface on which it is placed, greyish reddish, darker or lighter, green or yellow, as may be." Several individuals are not unfrequently met with on the same bush, where they cling tightly to the stems among the crowded leaves, being alike difficult to detect and to detach, and always exhibiting their displeasure at being disturbed by the aforesaid hissing sound. Absolutely still they remain, continues the writer just quoted, hour after hour, the only evidence of life about them being that revolving little globe of an eye, with its pupil turning as an axis, now up, now down, forwards or backwards, while its owner clings motionless as death. In repose the long tongue is folded up within the dilatable skin of the chin, where it has a special sheath for its reception; but it can be darted out with such speed as to take a fly at a distance of fully six inches. Although the majority of the species lay eggs, the pigmy chamæleon (*C. pumilus*) of the Cape, together with five nearly allied African species, produce living young, which may be as many as eleven in number. In confinement chamæleons quickly become tame, and, if allowed to rest in peace, after a few days cease to bite and hiss when handled, and soon venture to take a fly from their owner's hand.

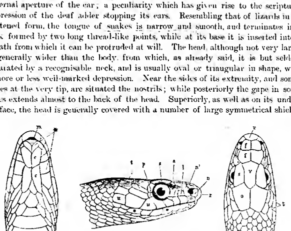
CHAPTER V.

SCALED REPTILES,—Order SQUAMATA—*continued*; THE SNAKES,—Suborder OPHIDIA.

Distinctive Characters and Structure.

ORIGINALLY regarded as representing a distinct ordinal group of the Reptilian class the snakes are now generally considered to form merely a suborder of the great assemblage of reptiles which includes both lizards and chameleons; and from their close structural resemblance to the limbless lizards there can be no doubt that the more modern view is the true one. As a matter of fact, it is by no means easy to draw a satisfactory distinction between lizards and snakes; and such characters as naturalists rely on for their differentiation are mainly such as are due to adaptation to the special needs of the latter group. Agreeing with lizards in their external covering of scales, snakes are characterised by their exceedingly elongated and slender bodily conformation; the head, which is generally more or less flattened, being often not defined from the body by a distinctly marked neck, while external limbs are wanting, and the body passes posteriorly by imperceptible degrees into the tail. Occasionally, however, external vestiges of the hind-limbs may persist, in the form of a pair of small spur-like processes near the vent; and internally there may be traces not only of the pelvis, but likewise of the thigh-bone, or femur. None of these characters will, however serve to distinguish snakes from the limbless lizards; and it is therefore necessary to point out how the two groups may be separated. The most characteristic peculiarity of snakes, as distinct from lizards, is the absence of a solid union between the two branches of the lower jaw, which are connected at the chin merely by an elastic ligament; this arrangement permitting of the separation of the two halves of the jaw, and thus allowing the mouth to be dilated so as to be capable of swallowing prey of much larger dimensions than the normal width of its aperture. In addition to this arrangement, in the majority of snakes the bones of the upper jaw and palate are likewise movable, thus further increasing the capacity of the gape. From the great majority of lizards snakes are, of course, widely distinguished by the absence of functional limbs; while from the comparatively few limbless representatives of the same suborder, they differ in having the tongue completely retractile within a basal sheath, as well as by the presence of additional articulations to the vertebræ, which are described below. Moreover, none of the limbless lizards have the large shields on the inferior surface characterising the majority of snakes, while most of them possess eyelids and an external aperture to the ear.

No snake has movable eyelids; that portion of the skin representing the lids extending as a convex transparent disc across the eye, and covering it as a watch-glass covers the face of a watch. When a snake changes its skin, which it does several times during the year, the discs over the eyes peel off with the rest, and appear as lenses in the dry slough. Equally characteristic is the absence of any external aperture of the ear; a peculiarity which has given rise to the scriptural expression of the deaf adder stopping its ears. Resembling that of lizards in its flattened form, the tongue of snakes is narrow and smooth, and terminates in a fork formed by two long thread-like points, while at its base it is inserted into a sheath from which it can be protruded at will. The head, although not very large, is generally wider than the body, from which, as already said, it is but seldom separated by a recognisable neck, and is usually oval or triangular in shape, with a more or less well-marked depression. Near the sides of its extremity, and sometimes at the very tip, are situated the nostrils; while posteriorly the gape in some cases extends almost to the back of the head. Superiorly, as well as on its undersurface, the head is generally covered with a number of large symmetrical shields,

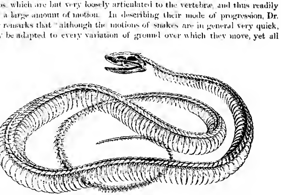


INFERIOR, LATERAL, AND SUPERIOR VIEWS OF THE HEAD OF A SNAKE.

r, rostral shield; ff^1, anterior and posterior frontal do.; *v*, interparietal do.; *s*, supraocular do.; *o*, parietal do.; nn^1, nasal do.; *l*, loreal do.; *a*, preocular do.; *p*, postocular do.; *uu*, upper labial do.; tt^1, temporal do.; *m*, mental do.; **, lower labial do.; *cc*, chin-shields.—After Gunther.

having their edges in apposition, and varying in relative size in the different groups. Although the blind snakes have a uniform cuirass of polished scales all round the body, while some of the sea-snakes also have the scales of the underparts similar to those of the back, in the great majority of the order the under surface of the body is protected by large transverse shields, extending completely across it from side to side.* These broad shields often extend as far backwards as the termination of the body proper; while at the commencement of the tail, and thence backwards to the extremity, they are replaced by a double row. These large inferior shields take an important part in the progression of snakes on land, and hence we see why they are wanting in the marine forms.

In all snakes the number of joints in the backbone is very large; and each of these, with the exception of a few near the extremity of the tail, is provided with a pair of rather long, slender, and curved ribs, the extremities of which correspond to the large inferior shields of the body in the species where these are present. Superiorly the ribs, as shown in the figure on p. 104, articulate by a single head with a facet on the side of each vertebra, in the same manner as in lizards. Only certain groups of lizards have the vertebræ with the additional articular facets on the front and back surfaces known as zygantra and zygosphenes, but in snakes (as shown in the figure below) these are invariably present; and it is owing to this complicated system of articulation that a snake is able to make the wonderful foldings and contortions characteristic of its kind without fear of dislocating its spine. It may be added that no snake has any trace of a breast-bone, nor any vestige of a pectoral arch, there being no rudiments of either blade-bone, coracoid, or collar-bone. When progressing on a firm surface, an ordinary snake, in common with the limbless lizards, walks entirely by the aid of its ribs, which are but very loosely articulated to the vertebræ, and thus readily admit of a large amount of motion. In describing their mode of progression, Dr. Günther remarks that "although the motions of snakes are in general very quick, and may be adapted to every variation of ground over which they move, yet all the varieties of their locomotion are founded on the following simple process. When a part of their body has found some projection of the ground which affords it a point of support, the ribs, alternately of one and the other side, are drawn more closely together, thereby producing alternate bends of the body on the corresponding side. The hinder portion of the body being drawn after, some part of it finds another support on the rough ground or a projection, and the anterior bends being stretched in a straight line the front part of the body is propelled in consequence. During this peculiar kind of locomotion, the numerous broad shields of the belly are of great advantage, as, by means of the free edges of those shields, they are enabled to catch the smallest projections on the ground, which may be used as points of support. Snakes are not able to move over a perfectly smooth surface." It may be added that a snake is only able to move by lateral undulations of its body in a horizontal plane; and that the pictures often seen in which these reptiles are depicted as advancing with the folds of the body placed in a vertical plane are altogether erroneous. In conformity with their elongated bodies, the



SKELETON OF SNAKE

internal organs of snakes are long and narrow; and it is remarkable that, as a rule, only one of the lungs is developed.

Teeth. Resembling the other members of the order to which they belong in that their teeth are never implanted in distinct sockets or grooves, snakes exhibit some considerable degree of variation with regard to the number and structure of their teeth. In the ordinary harmless forms there are generally two rows of short, slender, and sharply-pointed teeth in the upper jaw, the innermost of which are attached to the bones of the palate, while the lower jaw carries only a single row of such weapons. One or two of the outer row of upper teeth, either at the front or back of the series, may, however, be enlarged beyond the rest, and grooved or tubular; and it is probable that all snakes with such a dental armature are more or less venomous. Some most deadly poisonous serpents have, on the other hand, a type of dentition of their own; and there is no doubt that all snakes with teeth of this nature are extremely venomous. In such snakes the forepart of the very short maxillary bone of each side of the upper jaw is armed with an elongated tubular tooth, which ordinarily lies nearly flat on the surface of the palate, but can be erected, by a peculiar mechanism of the bones, when the jaws are opened. Although in this group the poison-fangs are always tubular, in some of the other venomous serpents they are merely grooved for the conveyance of the venom from the secreting gland; but there is a transition between the two types, as the closed tube is formed merely by the edges of the groove being elevated until they unite in the middle line. In poisonous snakes, on each side of the upper jaw, below and behind the eye, is situated the poison-gland—merely an ultra-development of an ordinary salivary gland; these glands in some cases being so developed as to extend far back along the sides of the body. The gland is overlain by a layer of muscles, for the purpose of forcing the secretion into the tooth (the base of which is always open) when required; this action always taking place when the snake opens its mouth to bite. The poison then flows along the channel or tube of the tooth, and is discharged at its extremity into the wound. Considerable force is used in the emission of the poison, as, when a snake is irritated, the fluid may be seen to spirt for some distance from its point of discharge. In some of the less specialised poisonous snakes, the venom-tooth, which has an open channel, is not greatly longer than the others, and is placed nearly vertically when the mouth is closed. Although the poison-teeth are commonly regarded as purely defensive weapons, their chief use is for the destruction of the prey of their owners, which is always killed before being swallowed. The venom-tooth of the more specialised poisonous snakes is exceedingly likely to be broken off during use; but to take its place there are always several others lying on the gum behind it in different stages of development.

Harmless and Poisonous Snakes. Before the doctrine of parallelism in development received from naturalists the attention it undoubtedly merits, snakes were generally divided into harmless and poisonous groups; but since we have become better acquainted with that important factor in evolution, it has been recognised that such a distinction is a purely artificial one, and has nothing to do with real affinity. Certain groups of snakes, such as the members of the viper family, may, however, be wholly poisonous; while in other groups, such as the typical snakes some species may be venomous and others innocuous. Many attempts have been made to draw up a list of characters by means of which the harmless members of the suborder can be distinguished at a glance from those which are hurtful. On this point Mr. Boulenger writes "that there is no sure method of distinguishing the two kinds of external characters; except, of course, by a knowledge of the various forms. And even then, a cursory examination is not always sufficient, since there is in some cases a striking resemblance between snakes of totally different affinities, by which even specialists may at first be deceived. In short, nothing but an examination of the dentition can afford positive information as to the poisonous or non-poisonous nature of an unknown snake."

Distribution

Geologically speaking, snakes are a comparatively modern group, being scarcely known below the lowest portion of the Eocene division of the Tertiary period, although one or two forms have been described from the underlying Cretaceous rocks and one has recently been recorded from the Gault of Portugal—a formation underlying the Chalk. It is noteworthy that one of the North American lower Eocene snakes has the additional articular facets of the vertebræ but very imperfectly developed; and there can be little or no doubt but that the whole group is an offshoot from the lizards. From the commencement of the Tertiary period, the group seems to have gone on steadily increasing in numbers; and it is now represented by some fifteen hundred species, ranging all over the world except New Zealand. Snakes are, however, much more abundant in the moist tropical regions of the globe than in colder regions, and it is there only that they attain their maximum development in point of size. India and the Malayan countries, where there are representatives of the whole of the nine families into which the suborder is divided, are the home of a greater number of both genera and species of snakes than any other part of the world. Tree-snakes are very common in this region, while the gigantic pythons are shared by it in common with Africa. The proportion of poisonous to innocuous species is likewise very high in the Oriental region, and has been estimated at about one in ten. Africa has scarcely half the number of snakes found in the Oriental region; and it is noteworthy that the forms inhabiting Madagascar have but little in common with those of the mainland; the so-called lycodonts, which are so common in Africa, being unknown in Madagascar, while some of the forms from that island are closely allied to South American types. Whereas pit-vipers are absent, an especial feature of Africa is the number of typical vipers which inhabit that country; and Australia, which differs so remarkably from India in its tortoises, possesses snakes (and likewise lizards) closely allied to African forms. Next to the Oriental region, tropical America is richest in ophidians, although the number of generic types is not so great. The proportion of poisonous species is, however, high, and has been estimated at as much as one in eight. In Southern Argentina and Patagonia snakes become scarce. Unlike its chelonians, the snakes of North America present a resemblance to those of Central America. Indeed, a feature of the whole of America is the absence of typical vipers, and the abundance of pit-vipers, although several genera of the latter are common to Asia. Europe and Northern Asia are comparatively poor in snakes, but (next to Africa) are characterised by the number of typical vipers and colubrine water-snakes.

Habits

Although a few members of the suborder subsist on eggs, snakes as a rule capture and devour living animals, which are in all cases swallowed whole, as these reptiles have no apparatus for rending or masticating their food. And it is in order that they may be able to swallow larger animals than would otherwise be possible, that they have the power of dilating their jaws in the manner already indicated. Not only can the jaws be thus enlarged, but the throat and stomach are capable of dilatation, owing to the circumstance that the lower ends of the ribs, from the absence of a breast-bone, are quite free; and in swallowing, a snake seems gradually to draw itself over the object to be devoured. The majority of snakes devour their prey alive, and a frog may be seen struggling in the stomach of a common English water-snake long after it has been swallowed. Other snakes, however, kill their prey either by striking it with their poison-teeth, after the manner of the vipers, or by encircling and smothering it in the folds of the body, like the boas. Although the process of digestion is very rapid, snakes feed but seldom; and it has been asserted that two or three frogs are sufficient to supply the needs of the English water-snake for a whole year. All snakes drink much, water being absolutely essential to their existence.

As might have been expected from their numbers, snakes exhibit great diversity in their modes of life; and while those of the tropical regions remain active throughout the year (unless they lie by during periods of drought) the species inhabiting colder regions hibernate during the winter. The most remarkable diversity from the ordinary mode of ophidian life is displayed by the blind-snakes, which lead a completely subterranean existence, very seldom making their appearance above the surface. The great majority of serpents are terrestrial in their habits, seldom entering the water or climbing trees; and these ground-snakes, as they may be called, are characterised by their cylindrical form and the width of the shields on the inferior surface of the body. Tree-snakes, on the other hand, which are mostly remarkable for their brilliant coloration, lead an almost completely arboreal life. Frequently they have the body very slender, or the shields on its under surface may be keeled in order to afford a firmer hold in climbing; while in other instances the tail is prehensile. It is among this group that the egg-eating species are found. Then, again, we have freshwater-snakes, which swim and dive with facility in the waters of rivers and lakes, where they spend a large portion of their time, feeding on such aquatic creatures as they can capture therein. As a rule, these snakes are distinguished by having the nostrils placed at the top of the muzzle, and likewise by the tapering form of the tail. Lastly we have the sea-snakes, which, while having the nostrils situated as in the last group, are distinguished by the lateral compression of their tails. In all cases extremely poisonous, these snakes are almost entirely pelagic in their mode of life, and seldom approach the land, although in one genus the shields on the under surface of the body are sufficiently developed to admit of terrestrial progression.

By far the greater majority of the members of the suborder lay eggs, of an oblong form and enclosed in soft leathery shells, which are hatched by the natural heat of the places where they are deposited. The pythons, however, incubate their eggs, and at such periods develop a temperature a few degrees above that of the surrounding air. On the other hand, both in the freshwater- and sea-snakes the eggs are retained within the body of the mother until they are hatched.

THE BLIND-SNAKES.

Families *TYPHLOPIDÆ* and *GLAUCONIIDÆ*.

The blind-snakes, which are now arranged under two families, are small, worm-like creatures, with cylindrical bodies and short heads and tails, entirely adapted for a subterranean burrowing life. Lacking the large interior transverse shields characterising ordinary snakes, the blind-snakes have the body and tail covered on all sides with round overlapping scales of equal size on both the upper and lower surfaces; while there are large shields on the forepart of the head, one of which on each side covers the rudimentary eye. The cleft of the mouth, which is very small, is placed on the lower surface of the head, and the jaws admit of scarcely any dilatation. An important point of difference from all the other members of the suborder is that teeth are absent in either the upper or lower jaws, while in all cases larger or smaller vestiges of the pelvis remain. The most important distinction is, however, to be found in the palate of the dried skull, which differs from that of all other snakes in lacking the so-called transverse or transpalatine bone, which connects the pterygoid or hindmost bone of the palate with the posterior extremity of the jawbone or maxilla. In the first, or typical family of the blind-snakes, the upper jaw, which is but loosely attached to the rest of the skull, is furnished with teeth, while the lower jaw is toothless; the pelvis being represented merely by a single bone on each side. On the other hand, in the second family (*Glauconiidæ*) while the lower jaw is devoid of teeth, there are a few teeth in the upper one, the pelvis being represented by a pair of bones on each side, of which the two anterior ones meet in the middle line. As regards their origin, it seems probable that the blind snakes have little or no near relationship with the other members of the suborder to which they belong.

The typical blind-snakes, or those belonging to the first of the two families, are inhabitants of all the warmer regions of the globe, and are represented by nearly a hundred species arranged under three genera. By far the greater number of these species belong to the genus *Typhlops*, which has a distribution coextensive with that of the family; the other two genera, namely, *Helminthophis* with five species and *Typhlophis* with one, being confined to Central and South America. The second family contains only the single genus, *Glauconia*, of which there are nearly thirty species, found in America, Africa, and South-Western Asia. Very little has been recorded in regard to the habits of these curious snakes, although it is ascertained that they lay eggs, which are few in number, large in size, and elongate in form. Although they generally remain in their subterranean burrows, in showery weather these snakes not unfrequently come to the surface for a short time. The remains taken from their stomachs show that they feed largely upon millipedes and ants, and they probably also consume the larvæ of many insects. Captive specimens have been observed to drink freely. The European blind-snake (*Typhlops vermicularis*) is an inhabitant of Greece and several of the adjacent islands, Asia Minor, Syria, Arabia Petræa, and the Caucasus as far as Transcaspia

THE PYTHONS AND BOAS.

Family *BOIDÆ.*

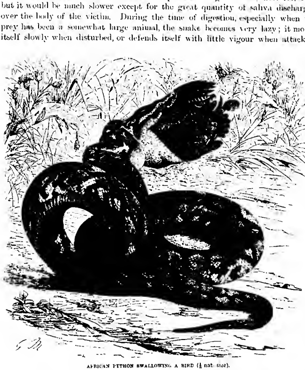
Including the largest of living snakes, this family is now regarded as being the most generalised of the entire suborder (exclusive of the blind-snakes), all the others presenting such characters as would admit of their having taken origin from ancestral types belonging to the one under consideration. In common with the remaining families, the boas and pythons differ essentially from the blind-snakes in that both jaws are fully toothed, and likewise in the presence of a transverse bone to the palate. The characters specially distinguishing the present from the other families of the suborder are, unfortunately, largely derived from the structure of the skull, and therefore require some degree of anatomical knowledge for their proper appreciation, while they cannot be described without the use of a considerable number of technical terms. It may be mentioned, however, that the lower jaw has on the inner side of each branch a thin bone known as the coronoid; while on the top of the skull the prefrontal bones, which lie on the outer side of the forepart of the frontals, articulate with the nasal bones, or those roofing the front of the cavity of the nose. In the hinder part of each side of the skull lies a large bone, termed the supra-

INDIAN PYTHON CRUSHING ITS PREY ($\frac{1}{16}$ nat. size).

temporal, from which is suspended the quadrate-bone for the articulation of the lower jaw; while a further important characteristic is to be found in the presence of vestiges of the pelvis and hind-limbs, the latter usually taking the form of a claw-like spur situated on either side of the vent. The family, which contains a very large number of genera and species, has an extensive geographical distribution, being represented in South-Eastern Europe, Central and Southern Asia, Africa, Australia, the West Indies, Western North America, and Central and South America; it is thus essentially characteristic of the warmer regions of the globe. Pythons belonging to extinct genera lived on the Continent and in England during the earlier part of the Tertiary period.

True Pythons. The large snakes to which the term python properly belongs are the typical representatives of the first of the two subfamilies into which the *Boidæ* are divided; the essential feature of this subfamily (*Pythoninæ*) being the presence on the upper aspect of the skull of a supraorbital bone lying on each side of the frontal bones, and forming the upper border of the socket of the eye. Agreeing with three other less important genera in the presence of teeth in the premaxillæ or anterior upper jawbones, and also in generally having two rows of shields on the under surface of the tail, the pythons are specially characterised by the distinctly prehensile tail, and likewise by the presence of deep pits in the rostral and anterior upper labial shields of the head. As minor characteristics, it may be mentioned that the teeth, none of which are grooved, gradually decrease in size from the front to the back of the jaws; while the eye is of moderate size, with a vertical pupil. The head is distinct from the neck, and has the extremity of the snout covered with large shields, while its hinder portion may be overlain either with symmetrical shields, or with small scales; and each nostril is placed in a half-divided nasal shield, separated from its fellow on the opposite side by a pair of internasal shields. The body in these snakes is more or less compressed, while the scales on the upper surface and sides are small and smooth; and the prehensile tail is of moderate length, or short, with the whole or greater part of the inferior shields arranged in two rows.

Distribution and Habits. Pythons, or, as they are frequently termed, rock-snakes, are represented by nine species, and range over tropical and South Africa, South-Eastern Asia, and Australasia. With the exception of the American anaconda, some of the pythons are the largest of all snakes, and although there has been much exaggeration in this respect, it is now ascertained that the Indian python (*Python molurus*), represented in the figure on p. 181, occasionally attains a length of 30 feet, while the West African python (*P. sebæ*) is stated to reach 23 feet. It is, however, but seldom that pythons of more than from 15 to 20 feet in length are met with, and these are sufficiently formidable creatures, since they have a circumference as large as a man's thigh, and easily kill such animals as small deer, full-grown sheep, and dogs of considerable size. They are, however, unable, according to Dr. Gunther, to devour animals of larger dimensions than a half-grown sheep. A python destroys its victim in much the same manner as do many of the smaller snakes, gradually smothering it by throwing over it coil after coil of its body. In swallowing, writes Dr. Gunther, pythons "always commence with the head [as shown in the figure of the African species], and as they live entirely on mammals and birds, the hairs and feathers offer a considerable impediment to the passage down the throat. The process of deglutition is, therefore, slow, but it would be much slower except for the great quantity of saliva discharged over the body of the victim. During the time of digestion, especially when the prey has been a somewhat large animal, the snake becomes very lazy; it moves itself slowly when disturbed, or defends itself with little vigour when attacked.



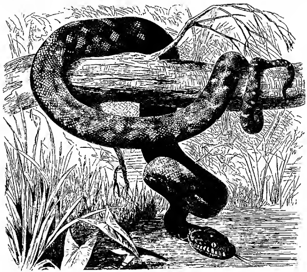
AFRICAN PYTHON SWALLOWING A BIRD (⅛ nat. size).

At any other time the rock-snakes will fiercely defend themselves when they perceive that no retreat is left to them. Although individuals kept in captivity become tamer, the apparent tameness of specimens brought to Europe is much more a state of torpidity caused by the climate than an actual alteration of their naturally fierce temper." In their general habits snakes of this genus are nocturnal, and they generally live on or among trees in the neighbourhood of water, frequently swimming in the water. The reticulated python (*P. reticulatus*) of Burma and the Malayan Archipelago, which attains a length of some 16 feet.

not unfrequently takes up its abode in buildings, whence it issues forth at night to capture such prey as it can find.

It had long been reported by travellers in India that pythons incubated their eggs, and although such reports were received with incredulity, their truth was established in 1841, when an African python in the Jardin des Plantes, Paris, laid fifteen eggs on the 6th of May, which she subsequently proceeded to incubate. When first laid, the eggs, which were completely separate, were soft, oval, and ashy grey, but they soon assumed a rounder form, and a clear white tint, at the same time hardening. The parent collected them into a cone-shaped pile, around which she rolled herself in such a manner as to conceal the whole number, with her head forming the summit of the cone. For upwards of six-and-fifty days this position was maintained without movement, except when persons attempted to touch the eggs. On July the 2nd, the shell of one of the eggs split, revealing a fully-formed python within; and on the next day the little creature came forth into the world. During the four succeeding days, eight more snakes made their appearance, but the rest of the eggs were spoilt. In from ten days to a fortnight the young pythons changed their skins, after which they caught and devoured some live sparrows, seizing and smothering them in the manner in which full-grown individuals destroy prey of larger size.

Species of Python. According to Mr. Boulenger, the number of species of python is nine, which may be divided into two groups, according as to whether the number of pairs of shields on the lower surface of the tail exceeds or falls short of fifty. The former group may be further subdivided into two sections, according as to whether the number of scales in a row round the thickest part of the body varies from thirty-nine to sixty, or from sixty-one to ninety-three. The first representative of the former of these subgroups is the Australian diamond-snake (*P. spilotes*), represented in the illustration on p. 185, which is characterised by the crown of the head being covered with scales or small irregular shields, and the presence of pits on two or three of the upper labial shields of the snout. This snake, which was formerly referred to a genus apart (*Morelia*), is an inhabitant of New Guinea and Australia, and is of comparatively small size, attaining a total length of only about 6½ feet; its coloration being extremely variable. The variety in which the skin is most spotted was long regarded as a distinct species, under the name of the carpet-snake. The other two members of this group are the amethystine python (*P. amethystinus*) and the Timor python (*P. timorensis*), both distinguished by the presence of large symmetrical shields on the crown of the head, and by four upper labial shields being pitted. The former, which grows to a length of about 11 feet, ranges from the Moluccas and Timor to New Guinea, New Ireland, New Britain, and the North of Queensland; while the latter is restricted to the islands of Timor and Flores. The second subgroup, or the one with from sixty-one to ninety-three scales round the body, includes three species, of which the Malayan reticulated python (*P. reticulatus*) has from sixty-nine to seventy-nine scales in a row, and four upper labials with pits. This species, which ranges from Burma and the Nicobar Islands to the Malayan region and Siam, is one of the largest of the genus, occasionally reaching upwards of 30 feet in length. In colour, it is light yellowish or brown above, ornamented with large circular rhomboidal, or X-shaped dark markings; while the head has a median black line, and the under-parts are yellowish, with small brown spots on the sides. It is, however, subject to considerable variation, a specimen from Siam in the London Zoological Gardens showing bright yellow lines on the sides. Young specimens show three longitudinal rows of light spots with black edges along the back, Somewhat smaller is the African python (*P. sebæ*), of tropical and South Africa, which attains a length of about 23 feet, and has from eighty-one to ninety-three scales in a row on the thickest part of the body, and only two of the labial shields pitted. This species occurs typically in West Africa, from which region came the specimen represented in the illustration on p. 183 in the act of swallowing a bird; and it was long considered that the South African python or Natal rock-snake was a distinct species. Its colour is pale brown above, with dark brown, black-edged, and more or less wavy crossbars, usually connected by an interrupted or continuous dark stripe running along each side of the back; while the sides are marked with large black spots and small dots. On the top of the head is a large triangular dark brown blotch, which is bordered on each side by a light stripe commencing above the nostril at the end of the muzzle, and passing above the eye, and there is a dark stripe on each side of the head, and a somewhat triangular blotch beneath each eye.



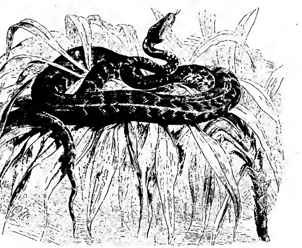
AUSTRALIAN DIAMOND-SNAKE (⅛ nat. size).

The upper surface of the tail has a longitudinal light stripe bordered on each side by a dark one, and the under-parts are spotted and dotted with dark brown. In India, Ceylon, the south of China, the Malay Peninsula, and Java, the last-named species is replaced by the Indian python (*P. molurus*), represented in the illustration on p. 181, in the act of strangling a chevrotain. While agreeing with the last in having only two of the labial shields pitted, it differs in having from sixty-one to seventy-five scales in a row, and likewise in that the rostral shield is broader than long, instead of with these two diameters equal. In colour, this python is greyish brown or yellowish above, with a series of large elongated squared reddish brown black-edged spots down the middle of the back, flanked by a series of smaller ones. The head and nape of the neck have a spear-shaped brown mark; and a brown band runs on each side of the head through the eye, while there is a vertical one of this colour beneath the latter. The under-parts are yellowish, with the sides spotted with brown. Known in India by the name of adjiga, this python ranges through Peninsular India, Rajputana, and Bengal, to the foot of the Himalaya, and is not uncommon; but in Ceylon, the Malay Peninsula, and Java, it is rare. It does not commonly exceed about 12 feet in length.

The three remaining species of the genus form the second main group, in which there are less than fifty pairs of shields on the lower surface of the tail; the number of shields in a row at the thickest part of the body varying from fifty-three to sixty-three, and neither of the species being of very large size. The best known of the three is the royal python (*P. regius*), of Senegambia and Sierra Leone, which is generally represented in the collection of the London Zoological Gardens; the other two being the rare Anchieta's python (*P. anchietæ*), of Benguela, and the Sumatran python (*P. curtus*).

Allied Genera. The subfamily of the *Pythoninæ* is represented by six other genera, which demand merely a brief reference; the first three of these agreeing with the typical genus in the presence of teeth in the premaxillary bones, while in the remainder that portion of the upper jaw is toothless. From the pythons the first three genera may be distinguished by the tail being but very slightly, if at all prehensile, and by the rostral shield of the head being either devoid of pits, or with only very shallow ones. The first genus (*Loxocemus*), as represented by a single comparatively small Mexican species (*L. bicolor*), has no pits in the labial shields, no loreal shield, and the nostril situated in a single nasal shield. *Nardoa boa*, of New Island, alone represents the second genus, and may be distinguished by the presence of pits in the lower labial shields, and by the laterally placed nostril being situated between two nasal shields. On the other hand, the third genus, *Liasis*, is represented by several species ranging from Flores and Timor to Papua and the north of Australia, and may be distinguished from the second by the nostril being placed more superiorly in a half-divided nasal shield. Finally, three genera in which the anterior jawbones, or premaxillæ, are toothless are *Chondropython*, with one Papuan species; *Aspidites*, represented by two species from the north of Australia; and *Calabaria*, with a single West African representative. The interest attaching to these snakes is the connection which they form between the pythons and the boas. Thus while the two first differ from the typical pythons and resemble the boas in the presence of teeth on the palate, the second and third likewise agree with the latter in having the shields on the lower surface of the tail mostly or entirely single; the tail itself being but slightly, if at all prehensile.

Tree-Boas. The tree-boas of tropical America may be taken as examples of the second subfamily (*Boinæ*) of the assemblage of snakes under consideration. The members of this subfamily can be distinguished from the preceding group solely by the absence of a supraorbital bone on the upper surface of the skull above the socket of each eye. They further differ from all the pythons, with the exception of two of the three genera last mentioned, in having teeth on the palate; and, with the exception of the whole three of the connecting genera, in the absence of teeth in the anterior upper jawbones, or premaxillæ. Moreover, the boas and their allies further differ from the typical pythons in having the shields on the lower surface of the tail for the most part single, thereby agreeing with the genera *Aspidites* and *Calabaria*; and thus showing that the small group to which the two latter belong forms such a close connection between the pythons and boas as to preclude their reference to separate families.



STREAKED TREE-BOA (½ nat. size).

In common with the majority of the thirteen genera, into which the subfamily is divided, the tree-boas are characterised by having the head distinctly defined from the neck, and the tail more or less prehensile. They are specially distinguished by the anterior teeth being much larger than the hinder ones, by the smooth scales of the body; by the presence of shields on the head; and by the labial shields being either devoid of pits or with only shallow ones. In form the body is more or less compressed, and the tail either moderate or long; while the eye is of medium size with a vertical pupil; and the shields on the head may be either small and irregular, or large and symmetrical.

These snakes are represented by nine species, the largest of which is the pale-headed tree-boa (*Epicrates angulifer*) of Cuba, attaining a length of about 7 feet; another well-known species being the streaked tree-boa (*E. striatus*), from San Domingo and the Bahamas. The thick-necked tree-boa (*E. cenchris*), must, however, be mentioned, its habitat ranging from Costa Rica to the northern districts of Peru and Brazil. The figured species, which attains a length of about 5 feet, is either pale brown above with dark olive-brown spots separated by narrow intervals from one another, or brown with wavy or zigzag yellowish crossbands, not unfrequently margined with blackish brown. Each side of the

DOG-HEADED TREE-BOA (¼ nat. size).

head usually has a more or less distinct streak behind the eye; while the under-parts are pale olive or yellowish, more or less spotted with brown or black.

Dog-Headed Tree-Boa.

Closely allied to the last the five species of the genus *Corallus* are distinguished by having deep pits in the labial shields of both the upper and lower lips. The body is compressed, with small smooth scales, and the prehensile tail is either short or more or less elongated. This genus has a somewhat remarkable distribution, four of its representatives being inhabitants of tropical America, while the fifth (*C. madagascariensis*) which is distinguished from the rest by the shortness of its tail, is restricted to Madagascar. The dog-headed tree-boa (*C. caninus*) is a native of the Guianas and Brazil, and usually attains a length of some 5 feet although it may be considerably larger. It belongs to a group of two American species distinguished from the other kinds inhabiting the same countries by the relatively shorter tail, which has only from sixty-four to eighty-two shields on its interior surface; whereas in the true tree-boa (*C. hortulanus*), and another species, there are at least a hundred of these shields. The species here figured is specially characterised by having the scales arranged in sixty-one or seventy-one rows, and by the number of shields on the under surface of the body ranging from one hundred and eighty-eight to two hundred and nineteen, while those on the tail vary from sixty-four to seventy-nine. In colour this snake is decidedly handsome, the upper-parts of the adult being bright green, ornamented with irregular spots and crossbars of white, and the under-parts bright yellow. In the young the ground-colour is yellowish, and the white markings are edged with dark green or purplish black. Most abundant in the neighbourhood of the Amazons, this species becomes more rare in Guiana, while southwards it likewise diminishes in numbers in lower Brazil. Feeding principally upon birds, the dog-headed boa is an excellent swimmer, and has been observed both in the Rio Negro and in the salt-water of the beautiful harbour of Rio de Janeiro. Although it frequently visits the huts of the Brazilian negroes in search of prey, it does not appear that this snake ever voluntarily attacks human beings. If, however, it is driven to bay and unable to escape, it is capable of inflicting very severe bites with its long front teeth, such wounds being difficult to heal.

Keeled Tree-Boas.

A third genus of tree-boas (*Enygrus*) is distinguished from both the preceding by the scales having distinct keels; the labial shields of the head being devoid of pits, and the tail short and prehensile, with a single row of shields on its inferior surface. This genus is represented by four species inhabiting the Moluccas, the Papuan region, and Polynesia.

Anaconda.

This gigantic snake is the sole member of a group of several genera, distinguished from the tree-boas by the teeth gradually decreasing in size from the front to the back of the jaws without any marked enlargement of those in the fore-part. Merely mentioning the allied tropical American genera, *Trachyboa*, *Ungalia*, and *Ungaliophis*, the first and last of which are each represented only by a single species, we may observe that the anaconda is specially distinguished as a genus by the large size of the rostral shield of the head, behind which one pair of the nasals come in contact with one another in the middle line, and by the very small size of the smooth scales of the body

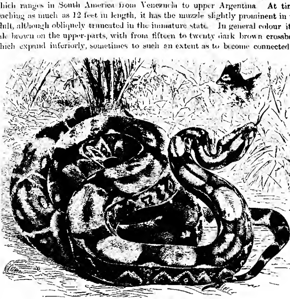
The head is markedly distinct from the neck; the nostrils are directed upwards and placed between three pairs of nasal shields, of which the hindmost are those which meet in the middle line; the small eye has the pupil vertical; the body is cylindrical; and the tail is short and slightly prehensile, with a single row of shields inferiorly. In colour the anaconda is greyish brown or olive above, with either one or two series of large blackish transverse spots and a single or double

THE HOME OF THE ANACONDA.

row of lateral eye-like spots having whitish centres and blackish rims. The upper part of the head is dark, and divided by a black streak terminating in a point on the muzzle, from the lighter cheeks; while another oblique black streak runs on each side behind the eye; the under-parts being whitish with blackish spots.

The anaconda (*Eunectes murinus*) is an inhabitant of the Guianas, Brazil, and North-Eastern Peru, and is essentially an inhabitant of tropical forest regions. That it is the largest of all living snakes there can be little doubt, but the precise limits of size to which it may occasionally attain cannot be ascertained. A stuffed example in the British Museum has a total length of 29 feet, and the species is commonly stated to reach 33 feet, while, if native reports are to be trusted, individuals of much larger size are occasionally met with. Although naturalists are generally indisposed to credit the existence of monsters of 40 feet, or even more, we confess that personally we are unable to share their incredulity, as it is very improbable that the largest specimens have come under European observation. From all accounts, it appears that the anaconda generally spends more of its time in the water than on land, frequently floating down rivers with the current, and at other times lurking in quiet pools with only its head raised above the surface of the water. In such situations, or resting on rocks, stranded tree trunks, or sandbanks, it lies in wait for its prey. It, however, frequently leaves the water to pass a longer or shorter period on shore, when it may be found either in trees among rocks, or even on hot sand; and it appears that when in a tree this snake will often dart down its head from a considerable height to seize a passing peccary or other animal. Bates tells us that the anaconda will occasionally seize human beings, and this statement is fully confirmed by other observers. In Brazil, where water is abundant throughout the year, this snake is active at all seasons, although it is stated to display the most activity during the hot months of December, January, and February. In other districts, however, according to Humboldt, during the dry season, it is in the habit of burying itself deep in the mud of the dried-up rivers, where it is sometimes disinterred by the natives in a torpid condition. Very little is known with regard to the breeding habits of the anaconda. Since, however, females have several times been killed, containing eggs with embryos far advanced inside them, it would seem that the young are born alive. When they first make their appearance in the world, the young are reported to take to the water, although they soon leave it to pass a large portion of their time in trees.

True Boas. Long supposed to be exclusively a tropical and South American group, the true boas are common to the hotter regions of America and Madagascar. From the anaconda, the boas may be distinguished by the whole of the nasal shields being separated in the middle line by small scales. The body may be either cylindrical or slightly compressed; and the short and more or less prehensile tail may have either the whole or a portion of the shields on its lower surface arranged in a single series. In America the genus is represented by five species, two of which range as far south as the inland districts of upper Argentina. All species are characterised by having the loreal region of the head covered either with a single small shield or with small scales, and by the number of rows of shields on the under surface of the tail ranging from forty-five to sixty-nine. On the other hand, in the Malagasy boas (*Boa madagascariensis* and *dumerili*) there are several shields on the same region of the head, while the number of rows of shields beneath the tail is only from twenty to forty-one. The best known representative of the genus is the common boa, or boa-constrictor (*B. constrictor*), which ranges in South America from Venezuela to upper Argentina. At times reaching as much as 12 feet in length, it has the muzzle slightly prominent in the adult, although obliquely truncated in the immature state. In general colour it is pale brown on the upper-parts, with from fifteen to twenty dark brown crossbars, which expand inferiorly, sometimes to such an extent as to become connected on the sides of the body, and thus to surround oval or elliptical spots of the light ground-colour; the expanded portion of each bar having a light longitudinal line. On the sides are a series of large light-centred dark brown spots, most of which alternate with the crossbars; and on the tail all the markings become relatively larger, of a brick-red colour, margined with black, and separated by yellowish intervals. From the muzzle to the nape runs a dark brown median streak, widening posteriorly, where it may be looped; another bar of the same colour passes on each side of the head through the eye, while there is a third below the latter, and the lips are marked by such bars: the rostral shield of the snout being also ornamented with a crescentic blackish mark. The under-parts are yellowish, with spots and dots, or merely dots, of black. The whole tone of coloration is dull, sombre, and adapted to harmonise with the shades of brown, black, and yellow on the bark of tropical forest trees.



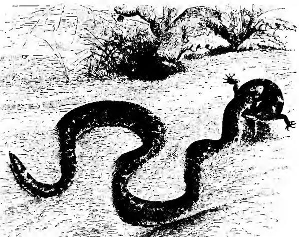
COMMON BOA ($\frac{1}{12}$ nat. size).

Could we but see the boa during the night in the depths of its native forests —at which time alone it is thoroughly active—we should doubtless obtain a very different idea of the creature than that which we gather from the inspection in the daytime of the lethargic specimens in menageries. Lying coiled on the branch of some large tree, with its head projecting ready to be darted on its prey with the rapidity of lightning, the boa is generally unobserved by the passing traveller unless it happens to make a dart at an unfortunate dog belonging to his party. Feeding generally on such mammals as agutis, pacas, rats, and mice, which are destroyed in the manner from whence is derived its trivial name, the boa, when it attains unusually large dimensions, is also capable of killing deer and large dogs, while it is always ready for such birds as it can capture, and does not disdain, when in captivity, a meal of eggs. The stories of its killing adult human beings and horses are, however, mere fabrications. Nothing is known of the breeding-habits of this snake and its kindred in a wild state; but from observations made on specimens in captivity, it appears that the eggs are generally hatched within the body of the parent, although one instance is on record where young and eggs were produced simultaneously. To European palates, snakes would probably be highly unacceptable as food, however temptingly they might be dressed; but in Eastern South America, the flesh of the boa is regarded as a most dainty dish, while its fat is reputed to be highly efficacious in the healing of various diseases. The skin is used to ornament saddles and bridles, and for other decorative purposes. None of the other members of the genus attain dimensions equal to those of the common boa, the Malagasy species being the smallest of all.

Keel Scaled Boa. The last representative of the section of the subfamily in which the head is well defined from the neck, and the tail more or less prehensile, is the keel-scaled boa (*Casarea dussumieri*), of Round Island, near Mauritius, distinguished as a genus by the keeling of the scales, and the long tail; its other general characters being similar to those of the true boas, except that the nasal shields of the head are separated by a pair of internasals. This snake, which attains a length of about 4 feet, and has a prominent and obliquely truncated muzzle, is either uniform pale brown above, or brown with two dark stripes and a lateral series of small spots down the body, a dark streak on each side of the head through the eye, and the under-parts either plain yellow or yellow spotted with black, the under side of the tail always having such spots.

Sand-Snakes. The snakes of this genus, together with those of three allied genera, which are the remaining members of the family, may be distinguished at a glance from the boas and their allies by the gradual passage of the head into the body without any constriction at the neck; while they are further characterised by the tail being, at most, only slightly prehensile. From their allies, the sand-snakes are distinguished by the small scales being either smooth or singly keeled, and by the head being covered with small shields of which the rostral is enlarged. The eye is small, and sometimes minute, with a vertical pupil; while the body is cylindrical; and the very short tail, which is frequently without any power of prehension, has a single row of shields on its lower surface. These snakes are represented by seven species, with a geographical distribution including Northern and Eastern Africa, and Southern and Central

Asia, as well as a part of the extreme south-west of Europe. The best known species is the Egyptian sand-snake (*Eryx jaculus*), which has a length of about 2 feet, and is an inhabitant of the Ionian Islands, Greece, South-Western and Central Asia, and the north of Africa. In colour it is very variable, the upper-parts being in some examples pale greyish, reddish, or yellowish brown, ornamented either with dark brown or blackish transverse blotches or alternating spots, while in other cases the general colour is brown with pale spots. A dark streak runs from each eye to the angle of the mouth; the under-parts are either uniform white, or white with blackish dots; and there is a more or less distinct dark



EGYPTIAN SAND-SNAKE (½ nat. size).

streak along each side of the tail. This species is exceeded in size by the Indian sand-snake (*E. johni*), which attains a length of over a yard, and inhabits the plains of North-Western, Central, and Southern India. This snake is generally banded, but the young may be of a uniform pale coral-red colour. Although resembling the boas in being nocturnal, these snakes are quite different in their mode of life, inhabiting open sandy plains, and feeding on small mammals, lizards, and worms. In search of their prey they frequently enter holes and crevices among rocks, and they will also burrow in the sand. They are perfectly harmless, and generally make no attempt to bite; but they are somewhat unsatisfactory creatures in captivity, owing to their habit of lying concealed among the gravel of their cage. The Indian species is frequently carried about by snake-charmers, who are in the habit of mutilating the short tail so as to make it look like a head; whence arises the legend of two-headed snakes. A second Indian species (*E. conicus*) was formerly referred to a separate genus (*Gongylophis*), on account of having a series of keeled scales between the eyes.

Allied Genera. Of the remaining members of the family, *Lichanura*, with one Californian species, differs from the sand-snakes by the smaller size of the rostral shield, which is longer than wide; while *Charina*, which is likewise Californian, has the head covered with large shields. On the other hand, *Bolieria*, as represented by a single species from Round Island, near Mauritius, differs from all the other members of the group in having three or four keels on the scales, the muzzle being covered with large shields.

Extinct Python like Snakes. In this place may be noticed certain gigantic snakes from the lower and middle Eocene rocks of Europe, described under the name of *Palæophis*, and represented by closely allied, if not generically identical forms in the corresponding strata of North America. Equal in size to those of the largest pythons, the vertebræ differ from the latter (shown in the figure on p. 18) by the much greater height of the upper or neural spine, which has not the backwardly-directed process at its summit characterising the pythons. From the shape of these vertebræ, it is pretty certain that these snakes had compressed bodies like the modern sea-snakes, while from the nature of the deposits in which their remains occur, there can be little doubt that they were marine in their habits. Whether they were really allied to the pythons and boas may be doubtful, but in any case it is probable that they indicate a separate family.

THE CYLINDER-SNAKES.

Family *ILYSIIDÆ.*

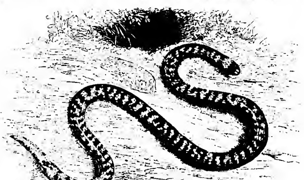
Agreeing with the pythons and boas in the retention of vestiges of the hind-limbs, the small group of cylinder-snakes appears to form a connecting link between the two former and the under-mentioned family of shield-tailed snakes; their essential point of distinction from the preceding being that the supratemporal bone of the skull is of small size, and included in the walls of the brain-case instead of standing out as a support for the quadrate-bone, which is much shorter than in the boas and pythons. Teeth are present on the palate as well as in the jaws; and the vestiges of the hind-limb usually take the form of a spur on each side of the vent. In general appearance, and in the arrangement of the scaling these snakes approximate to the boas; while as regards the structure of the skull they are intermediate between them and the next family. The distribution of the group is remarkable, being restricted to Ceylon and South-Eastern Asia in the Eastern, and to Tropical America in the Western Hemisphere. Three genera, of which two have one species, while the third has three, represent the family.

Coral Cylinder Snake. The single representative of the typical genus of the family is the beautiful coral cylinder-snake (*Ilysia scytale*), inhabiting the Guianas and Upper Amazonia, and attaining a length of something over 2½ feet.

The distinctive features of the genus are the presence of two teeth in the anterior upper jawbones, or premaxillæ, and the eye being situated in the middle of an ocular shield. The colour is a splendid coral-red ornamented with black rings, or incomplete ring-like black bands. From the little that is known concerning its habits, it appears that this snake is sluggish in its movements, and never wanders far from its retreat, which is situated under the roots of a tree or in a hole or cleft in the ground. It feeds on insects and blind-snakes, and produces living young.

Red Snake.

The true cylinder-snakes, as typically represented by the red snake (*Cylindrophis rufus*), differ from the preceding by the absence of teeth in the anterior upper jawbones, and likewise by the eye not being included in any of the head-shields. This genus has three representatives, and is distributed over Ceylon and South-Eastern Asia to the eastwards of the Bay of Bengal, the common red snake ranging from Burma and Cochin-China to the Malayan region. This snake, which attains a length of about 2½ feet, is either brown or black above, with or without light alternating crossbars; the under-parts being either white with black transverse bars or spots, or black with white bands; while the under surface of the tail is of a brilliant vermilion hue. All the snakes of this genus are burrowing reptiles, seldom showing themselves above the surface of the ground, and feeding on insects, worms, and the smaller mammals. In common with their allies, they have the body covered with polished, rounded scales, which (in conformity with their burrowing habits) are scarcely larger on the upper than on the lower aspect, although becoming wider on the inferior surface of the tail.



CORAL CYLINDER-SNAKE (½ nat. size).

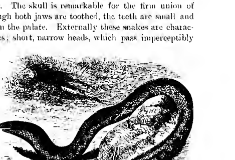
The third genus of the group (*Anomalochilus*), represented by a single species from Sumatra, differs from the preceding in the absence of a groove on the chin.

THE SHIELD-TAILS.

Family *UROPELTIDÆ*.

The snakes of this family, while agreeing with the boas and pythons in the structure of the lower jaw, are sharply distinguished by the loss of all traces of the limbs, and likewise by the complete disappearance of the supratemporal bone in the skull. By Mr. Boulenger they are regarded as directly descended from the preceding family of the suborder. The skull is remarkable for the firm union of its constituent bones; and although both jaws are toothed, the teeth are small and feeble, and very rarely present on the palate. Externally these snakes are characterised by their cylindrical bodies; short, narrow heads, which pass imperceptibly into the neck; and by the extremely short, truncated, or slightly tapering tail, which generally ends in a rough, naked disc, although in one genus it is covered with keeled scales. On the body the scales are small and polished, those on the lower surface being always somewhat larger than those above; the eye is minute, and the cleft of the mouth comparatively small, and incapable of much dilatation.

These snakes are represented by upwards of seven genera, some of which comprise a large number of species, and are restricted to Ceylon and the mountains of Peninsular India. They are purely burrowing creatures, generally living in soft earth, at a depth of several feet, and consequently but seldom seen unless specially searched for. They are frequently dug up in the cultivation of tea and coffee plantations, and may be found beneath logs and stones. On the mountains these earth-snakes, as they are frequently called, may be met with in the open grass-lands; and during the rainy season they not unfrequently leave their burrows to travel some distance on the surface. Of relatively small size, many of them are beautifully coloured with red and yellow, while those that are black display an iridescence like that of some of the smooth-scaled skinks among the lizards. The food of these reptiles appears to consist solely of earth-worms; and the eggs are hatched before quitting the body of the parent. There is a legend current among the natives of India to the effect that every time a cobra bites it loses a joint of its tail, and eventually acquires a head like that of a toad; and Sir J. E. Tennent was of opinion that this fable was based on the shield-tailed snakes, in which the jaws have lost the great power of dilatation so characteristic of serpents in general.



A SHIELD-TAILED SNAKE.

THE COLUBRINE SNAKES.

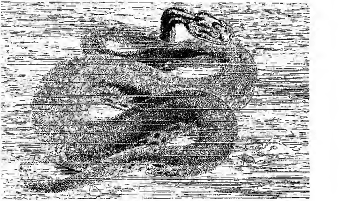
Family *COLUBRIDÆ*.

The skulls of the remaining snakes are markedly distinguished from those of the foregoing by the total absence in the lower jaw of the bone known as the coronoid; while in all cases a supratemporal is present on the upper surface of the skull. The present family, which includes by far the great majority of the species of the suborder, and comprises both harmless and noxious kinds, is specially distinguished from those to be mentioned later on by the circumstance that in the skull the upper jawbone, or maxilla, is fixed in a horizontal position, and also that the pterygoids reach either to the quadrate-bone or the lower jaw.

Before coming to the Colubrine family it should, however, be mentioned that there is one remarkable snake (*Xenopeltis unicolor*), from South-Eastern Asia, retaining in the structure of its skull traces of affinities with the boas and pythons. This affinity is displayed by the fact that the prefrontal bone, which lies immediately behind the nasal aperture of each side, is of large size, and extends forwards and inwards to articulate with the nasal bone in the same manner as the boas. Accordingly, this snake is regarded as the representative of a distinct family (*Xenopeltidæ*), which is considered to have originated from the *Boidæ* quite independently of the Colubrines.

From *Xenopeltis* the Colubrines are distinguished by the small size of the prefrontal bone of each side, which articulates merely to the outer front angle of the frontal bone without any contact with the nasal bone. In such a large group it is highly important to have some means of division into subgroups of higher value than genera; and, according to the modern classification, three such serial divisions may be indicated by the characters of the teeth. The first and most primitive of these series, which may be termed the solid-toothed colubrines (*Aglypha*), is characterised by the whole of the teeth being solid, without any trace of grooves, all its representatives being harmless. On the other hand, in the second series or hind-fanged colubrines (*Opisthoglypha*), one or more of the hinder teeth of the upper jaw are grooved; while in the third series or front-fanged colubrines (*Proteroglypha*) the front teeth of the upper jaw are grooved or tubular. Of the last series the whole of the members are poisonous, while many of those of the second are noxious in a minor degree. All these three sections contain species adapted to particular modes of life, so that we may have two or three snakes which, while externally very similar, are only distantly allied to one another.

Wart Snakes. The Javan wart-snake (*Acrochordus javanicus*) may be taken as a well-known representative of the first, or acrochordine subfamily of the solid-toothed colubrines, which includes only five genera, distributed over South-Eastern Asia and Central America. Unfortunately, the characters distinguishing this subfamily from the next are connected with the bones of the skull, and cannot therefore be verified without dissection, but in the study of snakes, according to the modern system, the student must accustom himself to such difficulties. The essential feature of the skull in the present group is the production of the postfrontal bone above the cavity of the eye; while, as a secondary feature, the scales of the body overlap one another but very slightly, if at all. The Javan wart-snake, which is the sole representative of the genus, is characterised by the absence of lower shields, by the head being covered with uniform granules, and by the very slight compression of the body. The head is rather short and broad, with the muzzle wider than long, and the small eyes directed forwards; while the nostrils are placed close together on the tip of the muzzle. The nearly cylindrical tail is short and prehensile. The colour is brown above and yellowish on the sides; the young having large irregular dark brown spots, which coalesce into bands on the back, and gradually tend to disappear in the adult. In size this snake may measure upwards of 8 feet. It is distributed over the Malay Peninsula, Java, and New Guinea; and, although it has been stated to be terrestrial, modern observations indicate that it is essentially aquatic, seldom even leaving the water, and feeding upon fish and frogs. A female in the possession of Cantor gave birth to twenty-seven young ones in less than half an hour, which were active and bit fiercely as soon as they came into the world.



JAVAN WART-SNAKE (⅓ nat. size).

An allied genus, represented by a single species (*Chersydrus granulatus*), ranging from Southern India to New Guinea, differs by the marked compression of the body and tail, and thus closely resembles the sea-snakes of the front-fanged series of the family, and likewise resembles them in habits, frequenting the mouths of rivers and the coast from Southern India to New Guinea, and being often found far out at sea. It produces living young, and subsists on fish. A third Oriental genus, likewise known merely by one species (*Xenodermus javanicus*), has large shields on the under surface. In the other two genera—*Stoliczkaia* from India, and *Nothopsis* from Central America—not only are there lower shields, but the granules on the head are replaced by large shields.

Water Snakes

The large group of water-snakes bring us to the second and by far the largest subfamily of the solid-toothed colubrines, which is known as the *Colubrinæ*, and is distinguished from the preceding group by the supratemporal bone not being produced over the region above the socket of the eye; while the scales are usually overlapping, and teeth are present throughout the entire length of the upper and lower jaws. The water-snakes belong to a large assemblage of genera of the subfamily characterised by the circumstance that in the skeleton of the backbone inferior projections or spines are present throughout its length, the vertebræ in the hinder region of the body having these spines represented by a more or less well-developed crest or tubercle. From their allies, the water-snakes are distinguished by having the hinder upper teeth larger than those in front, the equality in the size of the lower teeth, the rather large size of the eye, in which the pupil is round, the presence of a pair of internasal shields between the nostrils, the regular longitudinal series formed by the scales throughout the body, and by the teeth in each hinder upper jaw-bone varying in number from eighteen to forty, and forming a continuous series.

Represented by over forty species, the water-snakes have an almost cosmopolitan distribution, although they are unknown in South America, while in Africa south of the Sahara they are less abundant than in other regions, and in Australia they occur only in the northern districts. Dr. Günther writes that the typical water-snakes "are easily recognised by their stoutish cylindrical body, keeled scales, flat head covered with regular shields, wide cleft of the mouth, and numerous teeth, the strongest of which are at the hinder end of the maxillary bone. They frequent the neighbourhood of fresh water, and feed on aquatic animals—frogs, toads, and fishes. They do not overpower or kill their prey by throwing a coil of the body round it, but, having seized it, they at once commence to swallow it. They are excellent swimmers, but more frequently live near water than in it, in agreement with which habit, the position of their nostrils is not on the upper surface of the head, as in the true freshwater snakes, but on the side."

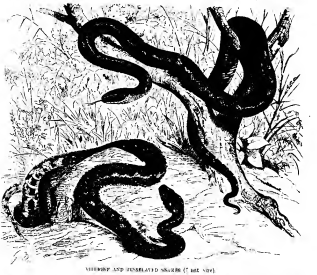
Ringed Snake

The best known and at the same time the typical representative of the group is the common ringed snake (*Tropidonotus natrix*), inhabiting Europe, Algeria, and West and Central Asia, and attaining a maximum length of 6½ feet. Belonging to a group of the genus in which the number of teeth in the hinder upper jawbone does not exceed thirty, this snake has a single anterior temporal shield on the head, usually seven upper labial shields, of which the third and fourth enter the aperture of the eye, and from one hundred and fifty-seven to one hundred and ninety shields on the lower surface of the body. The eye is of moderate size, and most of the scales are strongly keeled. The colour is usually grey, olive, or brown above, with spots or narrow transverse bands; the labial shields being white or yellowish, with their dividing lines black; while the under-parts are mottled black-and-white or grey. There are, however, several variations as regards the coloration of the neck. In the ordinary variety, for instance, there is a white, yellow, or orange collar, usually divided in the middle, behind which is a broad black collar; the latter being sometimes alone present. In another variety, mostly from the south of Europe, the collar is altogether wanting, or reduced to a small black patch on each side of the nape; while in the south-eastern race the collar, although well marked, is divided in the middle, and there is a yellowish streak along each side of the back.

In England the ringed snake is one of the most common reptiles, inhabiting woods, heaths, and hedges, especially where water is abundant. Although its chief food consists of frogs it also preys upon voles, mice, young birds, and fish, and is stated occasionally to consume eggs. When a frog is pursued by one of these snakes, it seems paralysed with fear, and, instead of making any effort to escape, sits still and gives vent to a shrill cry never heard at any other time. Generally the frog is seized by the hind-leg, and gradually swallowed by the snake without its position being changed. On this point Bell observes that "when a frog is in the progress of being swallowed in this manner, as soon as the snake's jaws have reached the body, the other hind-leg becomes turned forwards, and as the body gradually disappears, the three legs and head are seen standing forwards out of the snake's mouth in a very singular manner. Should the snake, however, have taken the frog by the middle of the body, it invariably turns it by several movements of the jaws, until the head is directed towards the throat of the snake, and it is then swallowed head-foremost." As a rule, the frog remains alive during the swallowing process, and it may sometimes be heard to croak when buried in the stomach of its captor, while instances are on record where a frog has returned after being thus entombed. When swimming, the ringed snake carries its head and neck raised above the surface of the water. The skin, as in the case of other serpents, is shed several times during the year, and is drawn off turned inside out, so that the lenses covering the eye appear concave instead of convex. Previous to changing its coat, the reptile becomes almost if not completely blind, and evidently ill at ease, and the change is accomplished by the old skin bursting at

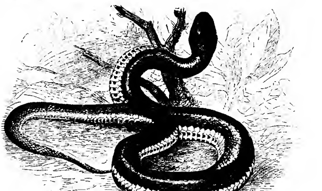
RINGED SNAKE SEIZING ITS PREY (⅕ nat. size).

the neck, and being pulled off by the owner wriggling its body between brushwood or dense herbage. Some sixteen to twenty eggs are annually deposited by the female of the ringed snake, these being attached together by a viscid substance. Although they are sometimes hatched solely by the heat of the sun, at other times the process of development is hastened by their being placed in a heap of decaying vegetable matter or manure. When the cold of autumn makes itself felt, this species retires for the winter, passing its time in a state of torpor ensconced in some hole in a hedge-bank, under the roots of trees, or some such place, where it remains till awakened by the returning warmth of spring. Not unfrequently several snakes occupy the same hole for the winter, and occasionally a considerable number have been found coiled up together in a mass.



VIPERINE AND TESSELATED SNAKES ([illegible] nat. size).

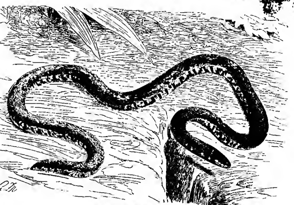
Tesselated and Viperine Snakes. The preceding species, as already said, belongs to the typical section of the genus, in which the teeth of the hinder upper jawbone do not exceed thirty in number, and are gradually enlarged towards the hinder end of the series, while the eyes and nostrils are lateral, and the internasal shields broadly truncated in front. As examples of the second section in which, while the number and characters of the teeth are similar, the small eyes and nostrils are directed upwards and outwards, and the internasal shields usually much narrowed in front, we select the tesselated snake (*T. tesselatus*) and the nearly allied viperine snake (*T. viperinus*), both of which are found in Europe, the former being a more southerly type than the latter, and extending eastwards into South-Western and Central Asia. The tesselated snake, which never grows quite so large as the common ringed species, is olive or olive-grey above, and may be either uniformly coloured, or marked with dark spots, usually arranged quincuncially, on the back. The nape of the neck is ornamented with a dark chevron; the upper labial shields are yellowish, with dark lines of division between them; and the under-parts are either yellow or red mottled and marbled with black, or almost wholly black. The viperine snake is rather smaller, having the upper surface grey, brown, or reddish, with a zigzag black band down the back, and a row of yellow-centred black spots down each side. There is a more or less distinctly marked oblique dark band on each side of the top of the head, and another on the nape of the neck; while the labials and under-parts are coloured like those of the tesselated snake. The general habits of both these species are very similar to those of the ringed snake; but in spring they are more generally found concealed in pairs beneath stones, and only take to the water in the summer. As other well-known North American representatives of the genus, we may refer to the garter-snake (*T. ordinatus*) and moccasin-snake (*T. fasciatus*); the former belonging to the first, and the latter to the second section. As an example of the third section in which the last two or third upper teeth are suddenly enlarged, the Indian long-banded snake may be mentioned.



KEEL-TAILED SNAKE (⅓ nat. size).

Oblique-Eyed Snake. Among the genera belonging to this section the only other that our space admits of even mentioning is the one containing the numerous species of oblique-eyed snakes. Generally having a smaller eye than the water-snakes, the members of this genus are distinguished by having only a single inter-nasal shield; the nostril being placed in a half-divided nasal shield, while the teeth of the lower jaw are of nearly equal size, and the scales lack the pits characterising those of an allied genus. There are from eighteen to twenty-five teeth in the hinder upper jawbone; the head is, at most, but slightly distinct from the neck; the body is cylindrical: and the tail, which has two rows of shields beneath, is of moderate length, the scales being usually striated and keeled. The genus is represented by eleven species, some of which are found in the New World, while others inhabit South-Eastern Asia, and others Tropical Africa.

The keel-tailed snake (*Helicops carinicauda*), inhabits Brazil. It attains a length of between 3 and 4 feet; and is characterised by having the scales on the back of the head smooth, and those on the body keeled and arranged in nineteen rows, the frontal shields being nearly or quite as long as the parietals, while there are from one hundred and twenty-six to one hundred and fifty-five shields on the lower surface of the body. The general colour is dark olive-brown above, with four more or less distinctly defined blackish stripes, and a yellow stripe along the two lower rows of scales; on the under-parts the ground-colour is yellow or red, with black spots or stripes on the body, and a black stripe on the tail. In the neighbourhood of the Rio Grande do Sul this species is one of the commonest of snakes; and while its general habits appear to be very similar to those of the water-snakes, like all the other members of its genus, it produces living young.



JAVAN PIGMY SNAKE (nat. size).

Pigmy Snakes. The snakes we have now to consider, while still belonging to the typical subfamily of the solid-toothed series, differ from the foregoing in that inferior spines are developed only in the vertebræ of the anterior half of the backbone, and are further characterised by the nasal bones being fully as large as the prefrontals. The preceding group are more or less aquatic in their habits, but those of the present assemblage are terrestrial or arboreal. The pigmy snakes have the hinder borders of the shields on the lower surface of the body entire the front lower teeth larger than the hinder ones, the eyes relatively small, and no internasal or temporal shields on the head The head is not distinct from the neck, each nostril is pierced in a very small nasal shield the body is cylindrical with the smooth scales arranged in thirteen rows, and there are two rows of shields on the lower aspect of the tail

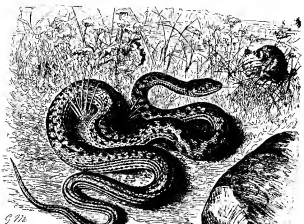
These snakes are represented by some thirty species, their headquarters being the islands of Java, Sumatra, and Borneo The figured species (*Calamaria linnæi*) is from Java. They are all of small size, frequently not exceeding a foot in length; and they are in the habit of hiding themselves among stones, beneath fallen tree-trunks, or in grass. Their small dimensions, together with the relatively narrow cleft of the mouth, and a want of dilatibility in the throat and body, indicate that they do not prey upon other reptiles. Gentle and harmless themselves, these snakes are often attacked and killed by kraits and other venomous members of their own tribe.

Sling-Snakes

On account of the well-known European smooth snake (*Coronella lævis*) being included among them, we mention as a second genus of this group the sling-snakes, of which there are about twenty known species ranging over Europe, Western Asia, Africa, and America, while one (*C. brachyura*) occurs in India. They belong to a group of genera in which the whole of the lower teeth are nearly equal in length; while they are specially distinguished by the presence of from twelve to twenty teeth in the hinder upper jawbone, which increase in size towards the back of the series. The head is short, and scarcely distinct from the neck; the eye being rather small, with a round pupil, and the head-shields normal. The body is cylindrical, and covered with smooth scales arranged in from fifteen to twenty-five rows, and furnished with pits at their tips; the tail is of moderate length; and whereas the shields on the inferior aspect of the body are rounded, those beneath the tail are arranged in a double series

The smooth snake, which attains a length of about 25 inches, is very variable in coloration, but the ground-colour of the upper-parts is generally brown. The most distinctive features are a large dark spot on the neck, often extending into a stripe, and two rows of dark brown spots arranged in pairs, and running down the body; there is also a dark stripe passing through the eye and the side of the neck, while the under-parts are either steely blue, or reddish yellow and white, in some cases spotted with black. This snake is found over the greater part of Europe, and is occasionally met with in some of the southern counties of England Although now and then found in damp or swampy localities, it frequents dry stony places where there is plenty of sunshine, resorting sometimes to old stone bridges and heaps of building material. Like its congeners, this snake is chiefly terrestrial in its habits; in disposition it is fierce, and its prey consists of other snakes and lizards. In the end of August or beginning of September the smooth-snake lays from three to thirteen eggs, which are so far developed that the included young almost immediately break the shells and escape.

Fierce Snakes. Nearly allied to the preceding are the ophidians which (from their German name *zornschlangen*) we may term fierce snakes; these demanding special notice on account of their having several representatives in Southern Europe. From the preceding genus they may be distinguished by the more slender form of the body, and the presence on the head of one or more suboculars below the preocular shield; while the arrangement of the longitudinal rows of scales in odd numbers differentiates them from an allied genus. The number of teeth in the hinder upper jawbone varies from twelve to twenty; the head is long and distinct from the neck, with the eye of moderate size or large, and its pupil



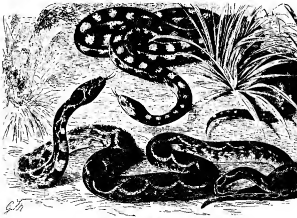
THE DARK GREEN SNAKE ($\frac{1}{4}$ nat. size).

round. The body is elongated and cylindrical, with the smooth or slightly keeled and pitted scales arranged in from fifteen to thirty-one rows. On the lower surface of the body the shields are rounded, or obtusely keeled on the sides; and the long tail has two inferior rows of shields. The fierce snakes are represented by some twenty species, ranging over Europe, Asia, and Northern Africa; several of them occurring on the Continent, although none are met with in the British Islands. Their headquarters may be considered to be the countries surrounding the Mediterranean basin. Deriving their name from the fierce and bold demeanour of the majority of their representatives, these snakes are terrestrial or partially arboreal in their habits, and feed chiefly on small mammals and birds. Of the European forms, a well-known example is the dark green snake (*Zamenis gemonensis*), inhabiting Hungary and the Mediterranean countries, and extending as far north as the south of Switzerland; while in the east it is represented by a variety known as the Balkan snake, which attains a larger size than the typical form. These snakes are distinguished from their allies by the regular arrangement of the shields on the head, and the presence of two preorbital shields, of which the lower is small and placed in the line of the labials; and they are further characterised by the relative shortness of the tail, which scarcely reaches a fourth of the total length. The smooth scales are arranged in from seventeen to nineteen rows. The ordinary form may attain a length of about 4 feet, but is generally smaller. In ground-colour the head and nape are greyish yellow, the back and tail greenish, and the under parts yellow, upon them being black markings, which, while irregular above, form regular oblique bars inferiorly, and in the hinder part of the body are arranged in longitudinal stripes which continue to the end of the tail. In some specimens, however, the ground-colour of the upper-parts is a beautiful yellowish green, while on the lower surface it is canary-yellow; in a third variety the whole upper surface is uniform olive-brown, and in some cases it is completely black, the under surface of the body being grey, with a steely blue lustre on the sides and the whole of the under-parts. This snake is very abundant in Italy, and may be met with in most gardens in the neighbourhood of Rome. Its habits vary to a certain extent according to locality; and while in the Russian steppes it frequents the hottest and driest spots, in Dalmatia and the Tyrol it is found in sunny, although by no means dry situations, either in woods or among old buildings.

Horseshoe Snake. The other European species is the horseshoe snake (*Z. hippocrepis*), common both to Southern Europe and Northern Africa and represented in the lower figure of the illustration on p. 208. From its allies it is distinguished by the presence of a series of small suborbital shields beneath the eye, which completely separate it from the upper labials, by the divided anal shields, the presence of from twenty-five to twenty-nine longitudinal rows of scales on the body, and likewise by the constancy of the coloration. Measuring nearly 6 feet in length, this handsome snake has the ground-colour of the upper-parts varying from greenish or greyish yellow through orange to reddish brown. As a rule, the head is marked by a dark oblique band between the eyes, behind which is a second band, convex in front, and reaching to the neck, and a third marked with light spots, so that a horseshoe pattern is formed between the spots and bands. On the back runs a row of yellow-edged dark oval patches, which tend to unite towards the hinder extremity; and on each side of this are a series of smaller spots, beneath which, again, are more upright dark marks, extending downwards to the lower surface. As the upper dark patches are very large the ground-colour is generally reduced to a series of rings, forming a very regular and pretty pattern. The under-parts are yellow or orange-red, spotted with black.

Rat-Snake. Here also must be mentioned the Indian rat-snake (*Z. mucosus*), now included in this genus, although formerly referred to the next. It is a large species, attaining a length of 6 feet or more. In colour it is brown above, frequently with more or less distinctly defined black crossbands on the hinder-part of the body and tail; the under surface being yellowish, often with black edges to the shields of the hinder-part of the body and tail. The range of this well-known species extends from India to Java. Common everywhere in India, and feeding on mammals, birds, and frogs, the rat-snake derives its name from its habit of entering houses in search of rats and mice. Like its allies, it is fierce and always ready to bite; and old specimens brought to Europe never become tame. When irritated, it utters a peculiar sound, which has been compared to that produced by gently striking a tuning-fork. A smaller allied Indian species (*Z. corrus*) differs by having the scales arranged in fifteen, instead of seventeen rows.

Running Snakes Nearly allied to the preceding are the American running snakes, of which the pantherine snake (*Ptyas pantherinus*) is a familiar and handsome example. From the last genus the running snakes are chiefly



BLACK-MARKED AND HORSESHOE SNAKES (¼ nat. size).

distinguished by their teeth and the larger size of the eyes. They are all large and powerful reptiles, with cylindrical body, clearly defined head, large eyes, regularly tapering tail, which is at least equal to a fourth of the total length, the scales smooth and arranged in from fifteen to seventeen rows, normally-arranged head-shields, unkeeled inferior shields, and about twenty-one equal-sized teeth in the hinder upper jawbone. The pantherine snake, which is an inhabitant of the hottest regions of the Guianas and Eastern Brazil, and is especially common in the neighbourhood of Rio de Janeiro, is characterised by having fifteen rows of scales on the body, the lack of the small lower preorbital shield, and its general form and coloration; its length being as much as 7 feet. The ground-colour is yellowish grey on the upper parts; on the front of the head are three dark crossbars, while two broad longitudinal stripes run along the hinder part of the head and neck;

the ornamentation of the back takes the form of a row of large greyish brown black-edged spots, which are lozenge-shaped on the neck, but further back become irregular, and confluent with two lateral rows of spots. The yellowish white shields of the edges of the jaws have black lines of division, and behind each eye a blackish brown streak runs to the angle of the mouth. This snake frequents swampy situations well covered with trees and bushes, and is remarkably swift and active in its movements. In its general habits it appears to resemble the ringed snake, feeding almost entirely on frogs and fish.

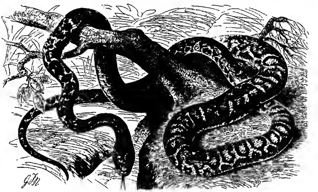
Climbing Snakes The typical representatives of the family are the climbing snakes, of which there are a large number of species, distributed over the great part of Europe, Asia, and North and Tropical America. Agreeing with the preceding genus in having the teeth in the hinder upper jawbone of nearly equal size, the climbing snakes have from twelve to twenty-two of these teeth, the teeth of the lower jaw being likewise subequal; and they are further specially distinguished by having the scales of the body arranged in from fifteen to thirty-five longitudinal rows, and furnished with pits at their extremities, those in the middle line of the back not being larger than the others. The long head is well defined from the neck, with a moderate-sized eye, of which the pupil is circular, and the shields normally arranged; the elongated body is slightly compressed, with its scales either smooth or keeled; and whereas the shields on the lower surface of the body usually have a more or less well-marked keel on the side, those of the tail are arranged in a double row. All these snakes are fierce in their disposition, and while all can climb well, some are almost entirely arboreal; others again, frequent the neighbourhood of water, and are good swimmers. The food of all consists of small mammals and birds. Formerly the chain-snake (*Coronella getula*), of the United States, common in the neighbourhood of New York, and attaining a length of about 5 feet, was included in this genus, but is now referred to *Coronella*. The dark ground-colour, which varies in tint from reddish brown to blackish brown and even black, shows on the upper surface a number of yellow crossbands, which on the lower part of the sides unite with similar longitudinal stripes, and thus form a regular light-coloured chain extending to the very tip of the tail. The shields on the top of the head are deep chocolate-brown, with a few yellow spots; the labial shields are dusky or yellowish white, bordered with blackish brown, and the underparts dirty yellowish white marbled with brown.

Among the European representatives of the genus, the yellow, or Æsculapian snake (*Coluber longissimus*) is recognised by the small head, imperfectly distinguished from the neck, and rounded at the muzzle, as well as by the stout body, rounded tail, and the nature of the scaling. On the head there is no small preorbital shield, and of the eight upper labials the fourth and fifth enter the circle of the eye; the body has from twenty-one to twenty-three rows of smooth scales, and the anal shield is divided. Generally, the upper surface is brownish yellow, with a tinge of grey, and the lower aspect whitish, the hinder-part of the head having a yellow spot; while the back and sides are marked with small whitish dots, which in some places are very distinctly defined, and assume the form of the letter X. There is, however, great individual variation in colour, and a dark and a light variety may be recognised. In the south of Europe, where it attains a length of about 4 feet, this snake prefers rocky, or at least stony districts abundantly covered with bushes; but in Schlangenbad, the only German locality where it is found in any numbers, old walls are its favourite resorts. As it feeds chiefly on voles and mice, it is a decided benefactor to the agriculturist and gardener. It also consumes, however, a certain number of lizards, as well as such birds as it can contrive to capture, and occasionally plunders a nest and sucks the eggs. It is

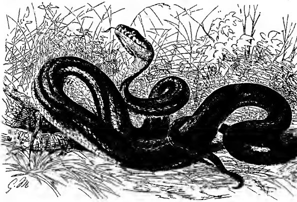
ÆSCULAPIAN SNAKE (1/[illegible] nat. size.)

very fond of climbing bushes, and low boughs or stumps of trees, as represented in our illustration; and in thick forests will go from bough to bough, and then from tree to tree without descending to the ground. Indeed, it is such an adept in climbing that it frequently captures swift-running lizards on the stems of trees.

Another South European species is the four-lined, or leopard-snake (*C. leopardinus*). Remarkable for the beauty of its coloration, which, however, is subject to great individual variation, this snake attains a length of about a yard, and differs from all its congeners in the absence of a lower preocular shield on the head, and the presence of eight upper labial shields, of which the fourth and fifth enter the circle of the eye. There are from twenty-five to twenty-seven longitudinal rows of scales in the thickest part of the body, and the anal shield is divided. Of the numerous variations, there are two which are most constant, the first being the typical but rare four-lined race. In this form the ground-colour is brownish grey, upon which are usually four black longitudinal stripes, here and there interrupted; although these are sometimes replaced by two dark or blood-red lines. On the sides are small blackish spots; the under surface of the head and forepart of the body is either yellowish white or bright yellow, but each under-shield is marked with four or five irregular blackish spots, which become so large posteriorly that the whole surface appears steel-blue, the yellow only showing on the edges of the shields. In the second variety, or leopard-snake, the ground-colour is mahogany-red, mottled on the upper surface with blood-red black-edged spots, which may either be arranged in two rows, or coalesce into transverse bands; while on each side there is a row of smaller, blackish, crescentic spots alternating with those of the back. The range of this species is bounded to the west by the mountains of Southern Italy and Sicily, and to the east by Asia; both varieties occurring together in most districts between these limits, although in Greece and Dalmatia only the leopard-snake is known.


LEOPARD-SNAKE.

Among the largest of European ophidians is the four-rayed snake (*C. quatuorradiatus*), which attains a length of between 6 and 7 feet, and is of an olive-brown or flesh-coloured hue above, often marked with a pair of longitudinal blackish brown stripes, a black line running from the eye to the mouth, and the under-parts being straw-yellow. There are, however, many variations from this typical coloration; some specimens being entirely black, while the young generally have black crossbands on the head, three rows of large brown spots on the back, the sides likewise spotted, and the under-parts with a blackish steel-grey tinge. The distinctive specific characters are the presence of a small preorbital shield on the head; the arrangement of the scales of the middle of the body in from twenty-three to twenty-five longitudinal rows—these scales being smooth in the young but strongly keeled in the adult—and the divided anal shield. The distributional area of this snake includes the whole of Southern and South-Eastern Europe, from Lower Italy and Dalmatia to Turkey, as well as Greece and the adjacent islands, and extends to the interior of Asia Minor, but there is some doubt whether the species occurs in the Caucasian region. All observers are in accord that the four-rayed snake



FOUR-RAYED SNAKE (⅓ nat. size).

is not only harmless but useful, since it destroys rats, mice, voles, and smaller snakes. It also preys upon moles, lizards, and small birds.

Black-Marked Snake. Another European species of the family is the black-marked snake (*Coluber scalaris*), which belongs to a separate group characterised by the following features. The rostral shield of the head is of a large size, convex, and pointed in front, while it extends backwards between the prefrontal shields, where it terminates in a point. The tail is relatively shorter than in the typical group. The black-marked snake, formerly separated as *Rhinechis*, and represented in the upper figure of the illustration on p. 208 has the cylindrical body relatively thick, the tail short and blunted, and the flattened head broad behind and sharp in front. The body-scales, which are arranged in from twenty-five to twenty-nine rows, are long, four-sided, and smooth; the shields on the under surface of the body are bent at the edges; while those beneath the tail form a double series. As regards colour, there is much variation; the ground-colour varying from bright grey or greenish grey, through reddish or yellowish brown, to olive or reddish yellow; while the markings of the head often take the form of a perpendicular black streak through the eye, and another from the eye to the mouth, the neck having a dark crossband and a row of similar spots running down the back, beneath which are another series of smaller ones, followed inferiorly by a third and fourth row. With age these spots tend gradually to disappear, till finally there remain only two dark brown or blackish rows running from the neck to the tip of the tail. In length this snake measures rather more than 4 feet. Everywhere rare, the black-marked snake seems to be confined to Spain and the opposite parts of Africa. While resembling the climbing snakes in the general nature of its food it also preys upon grasshoppers; and it will follow voles and mice into their burrows. A good climber, it is stated to be more rapid in its movements than any other of the European snakes; and its keenness of vision is remarkable.

SIPO, OR BRAZILIAN WOOD SNAKE (¼ nat. size).

Wood-Snakes. Whereas the preceding members of the family only climb trees in search of food the American wood-snakes are purely arboreal forms, especially adapted by their coloration to such a mode of life. Although they resemble the climbing snakes in possessing equal-sized solid teeth, they differ in the larger eye, which may be of very great size, their distinctly compressed and more slender body, and the small number of its longitudinal rows of scales, which does not exceed from ten to twelve. The five known species are inhabitants of the West Indies and the forest districts of Central and South America, all being characterised by their more or less uniform olive-green coloration. In the forests of Brazil, the Guianas and Venezuela, as well as in the Lesser Antilles, lives the sipo, or Brazilian wood-snake (*Herpetodryas carinatus*), which we select as a well-known example the genus. Frequently attaining a length of about 7 feet, and remarkably beaut in coloration, this snake generally has the upper-parts of a bright verditer or olive-green, shot with a tinge of brown on the back, while the under-parts are greenish or bright yellow; the greenish hue prevailing in the middle of the body, and the yellow elsewhere. Throughout there is a shimmering play of colours of all shades of green passing into metallic brown; while the middle line of the back has a brighter longitudinal streak, frequently bordered on each side by a darker band. In the West Indies this species undergoes a remarkable change of hue, becoming blackish brown or black above, with the under-parts steel-grey; the upper lip and edges of the jaws alone preserving the original yellowish green. The scales are arranged in twelve rows, and are mostly smooth, although the two middle rows on the back are keeled; the eye being of very large size. Next to the coral-snake, the sipo is the most abundant of Brazilian ophidians, and may be met with both on sandy jungle-clad ground close to the shore at Rio de Janeiro and Cape Frio, where specimens of upwards of 10 feet in length have been observed. In addition to sandy localities it also frequents swampy spots near the sea. In its movements it is so rapid that, when startled, it seems to disappear like a flash of lightning. It feeds largely upon frogs, as well as upon lizards and young birds, and lays only five eggs, which are remarkable for their cylindrical and slender form.

Tree-Snakes

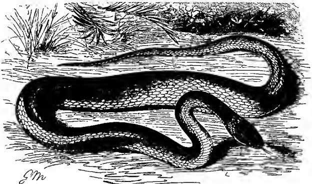
In the Old World and Australia the wood-snakes are replaced by the solid-toothed tree-snakes, forming the genera *Dendrophis* and *Dendrelaphis*; both of which are distinguished from all the preceding types by having the hinder border of each of the shields on the lower surface of the body with a notch on each side, corresponding to a suture-like lateral keel; the scales of the body being arranged in from thirteen to fifteen rows. While in the first-named of the two genera all the teeth in the hinder upper jawbone are approximately equal in length, and the row of scales in the middle line of the back larger than the others, in the second genus the foremost teeth in the hinder upper jawbone are enlarged, but the middle row of scales on the back are similar to the rest. All these snakes have large eyes, and elongated and often compressed bodies, and their general coloration is some shade of green or olive, often with a bronzy tinge; their habits being mostly arboreal. Of *Dendrophis* nine species are known, ranging from India to Australia; while *Dendrelaphis* is represented by five species ranging from India and the Malayan region to the Philippines.

Egg-Eating Snake.

The last representative of the solid-toothed series of the Colubrines that we have space to mention is the curious little egg-eating snake (*Dasypeltis scabra*), of South Africa, which represents a subfamily (*Dasypeltinæ*) by itself. The essential character of the subfamily is the rudimentary condition of the dentition, the front of both the lower jaw and upper jaws being devoid of teeth. To compensate for this lack of ordinary teeth, the egg-eating snake is, however, provided with a series of about thirty of what may be termed throat-teeth; these being the lower spines of the vertebræ, which project into the œsophagus, and are tipped with enamel. The scales are strongly keeled. This little snake is about a couple of feet in length, and has a body not much thicker than a man's finger. Although it lives in trees, and feeds on the eggs of small birds, it will when pressed by hunger descend to the ground and rob hens' nests. That such a tiny creature should be able to swallow a hen's egg seems incredible, but nevertheless a specimen has been taken with the egg actually within its jaws, and the whole head so swollen as to render the mouth incapable of being closed; while an example in the London Zoological Gardens swallowed pigeons' eggs without any apparent difficulty. When swallowed, the egg is split longitudinally by the row of teeth in the throat, and the whole of the contents secured. After being thus broken, the two halves of the shell, generally fitted into one another, are rejected.

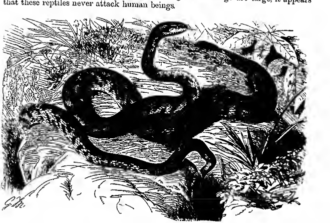
Moon-Snakes.

The pale snakes, or, as they are called in Brazil, the moon-snakes, may be taken as our first representatives of the second of the three great parallel series into which the Colubrine family is divided. This back-fanged series, or Opisthoglossa, is characterised by having one or more pairs of the hinder upper teeth longitudinally grooved, and thus capable of acting as poison-fangs. Many of these snakes are indeed extremely venomous, their bite being capable of producing death in a few minutes. They are divided into two subfamilies, of which the first, or *Dipsadinæ*, are characterised by the lateral position of the nostrils; and they are either terrestrial or arboreal in their habits, while their distribution is world-wide.



CROWNED MOON-SNAKE (⅔ nat. size).

Belonging to the first of the two subfamilies, the moon-snakes are characterised by the slender and somewhat compressed form of the body; the flattened head, which is but imperfectly differentiated from the neck, is broad behind and narrow in front, although somewhat pointed at the muzzle; while the upper jaw projects considerably over the lower. The scales, moreover, are smooth; both the anal shield, and the shields on the lower surface of the tail are single; and the eye, as in most of the other members of the subfamily, has the pupil vertical. The few representatives of the moon-snakes are confined to South America; the species here figured (*Scytale coronatum*) being an inhabitant of the eastern of that continent In size this snake is comparatively small, measuring only about 2 feet in length; its distinctive characteristic being that on the hinder portion of the body, or anterior part of the tail, the middle row of scales are not greatly enlarged. In young individuals the ground-colour is red, with a dark brown circular spot on the back of the head, another on the crown, and a ring on the neck, behind which are smaller spots of the same colour. With age the colour darkens, and the markings disappear, till in the adult the upper surface is black, and the lower side white. Very common in the neighbourhood of Bahia, this snake, like the other members of the subfamily, is almost exclusively nocturnal: and its food consists solely of lizards. Although their fangs are large, it appears that these reptiles never attack human beings.



CAT-SNAKE (½ nat. size).

Cat-Snake. As one of the few European representatives of the group under consideration, reference may be made to the so-called cat-snake (*Tarbophis vivax*), which is the sole member of its genus. It is characterised by its spindle-shaped body, the clear distinction between the flattened head and the neck, the relatively short tail, and the small size of the eyes. In place of a lower preocular shield, the elongated loreal extends backwards to the eye, so as to come in contact with the upper preocular; this arrangement being unknown in any other European snake. In the lower jaw the front teeth are much longer and more bent than those which follow; while the fangs in the hinder part of the upper jaw are also elongated and much curved. Sometimes reaching a little over a yard in length this snake is of a dirty brownish yellow or grey ground-colour, with small black dots and a chestnut-brown spot on the shields of the head, while the neck has a large blackish or reddish brown patch, and rows of smaller spots of the same colour ornament the back. There is also a dark band from the eye to the corner of the mouth; each side of the body has a row of small spots, and the under-parts are whitish with a brown marbling. The cat-snake ranges from the shores of the Adriatic to the neighbourhood of the Black and Caspian Seas, and Africa as far south as 45 N. It inhabits rocky and sunny spots, and feeds mainly if not exclusively on lizards. Although slower than the water-snakes, its movements are more rapid than those of the vipers. The virulence of its poison is shown by the circumstance that a lizard bitten by one of these snakes died in a minute and a half.

Nocturnal Tree-Snakes. The tropical regions of the Old World are the home of the typical genus (*Dipsas*) of the subfamily, which is characterised by the long and compressed body and tail, the sharp distinction of the head from the neck, the moderate or large size of the eye, with its vertical pupil, and the normal arrangement of the shields on the head, in which the hinder nasal is more or less markedly hollowed. The number of teeth in the hinder upper jawbone varies from ten to twelve, the two or three hinder pair being elongated and grooved; while in the lower jaw the front teeth are the largest. The scales on the body are arranged in from seventeen to twenty-seven longitudinal rows, those of the middle row of the back being larger than the rest; and the medium-sized or long tail has its inferior shields in two rows. These snakes are represented by about twenty species, inhabiting Southern Asia, New Guinea, Northern Asia, and Africa. The majority are inhabitants of forests or scrub-jungle, and are almost entirely arboreal; but a few are terrestrial, and frequent open country. Many of these snakes attain a length of 6 or 7 feet, and their prevalent ground-colours are brown and black. The Indian forms at least are purely nocturnal, and their food consists of mammals, birds, and, more rarely, lizards, and occasionally birds' eggs. It is noteworthy that some species prey entirely on mammals, while others confine their attention to birds. Eight species of the genus are recorded from India, Ceylon, and Burma; while a well-known Malayan form is the ularburong (*Dipsas dendrophila*).

Back-Fanged Tree-Snakes. These snakes are represented by two important genera, of which *Philodryas* is mainly characteristic of the tropical parts of America, although it also occurs in the West Indies and Madagascar; while the whip-snakes (*Dryophis*) are confined to India and the Malay countries. In the American genus the hinder fangs are not very large, being not double the height of the solid teeth in front of them. The body and tail are elongated and more or less compressed, the eyes large, and the smooth or keeled scales arranged in from seventeen to twenty-one rows; while the prevailing colour is green. The genus is represented by some fifteen species, among which the green snake (*P. viridissimus*) is a well-known form. This species attains a length of nearly three feet, and has upwards of two hundred shields on the lower surface of the body.

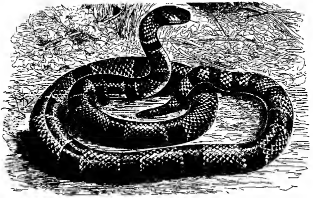
In the Indian whip-snakes the teeth in the posterior upper jawbone vary in number from twelve to fifteen, one or two near the middle being much enlarged and fang-like. After these comes an interval devoid of teeth, and at the hinder-end of the jaw the two last teeth are grooved. In the lower jaw the third or fourth tooth is enlarged and fang-like, those in the hinder-part of the series being small and uniform. The head is long, and markedly distinct from the neck; and the eye rather small, with a horizontal pupil. The scales investing the elongated and compressed body are smooth and without pits, and arranged in fifteen oblique rows, those down the middle of the back being slightly enlarged. The shields on the under surface of the body are rounded, and those beneath the tail form two rows. Deriving their name of whip-snakes from the extreme elongation and slenderness of the body and tail these serpents move awkwardly enough on a flat surface, although when coiling and climbing among the branches of trees their rapid movements are graceful in the extreme. While retaining their hold by means of a few coils of the tail thrown round a branch, the length of their body enables them with ease to reach another at a considerable distance, or to dart forth their head in order to seize any hapless bird or lizard that may be within striking distance.

Sharp Nosed Snakes. Nearly allied to the preceding are the sharp-nosed snakes (*Oxybelis*), of which seven species inhabit Central and South America, while the eighth is found in Central and Western Africa. These have small heads, with the snout narrow and elongated, and the rostral shield projecting considerably beyond the lower jaw. The neck is thin and slender, the body greatly elongated and laterally compressed, and the long and thin tail tapering to a fine point. The upper jaw carries seventeen solid teeth of nearly equal size, and four large fangs. In appearance and habits these snakes closely resemble the whip-snakes.

Oriental Fresh Water Snakes. Brief reference must be made here to a group of nine genera of aquatic snakes from India, Burma, China, New Guinea, North Australia, and the adjacent countries, which constitute a second subfamily (*Homalopsinæ*) in the hind-fanged series. From the preceding subfamily they may be readily distinguished by the position of the nostrils on the upper surface of the muzzle; while they are further differentiated by their thoroughly aquatic habits. It will be unnecessary to particularise the various genera; but it may be mentioned that the typical genus, *Homalopsis*, belongs to a group in which the two nasal shields of the head are in contact; and that in a second group, as represented by *Cantoria*, they are separated by an internasal shield. Most of these snakes are of small size, few of them exceeding a yard in length, while many are considerably smaller. Although mainly fresh-water snakes, seldom coming to shore, a few members of the group enter the sea. Many of them are furnished with prehensile tails, by means of which they attach themselves to convenient objects; and the majority feed exclusively on fish, though a few prefer crustaceans. Their young are produced alive in the water.

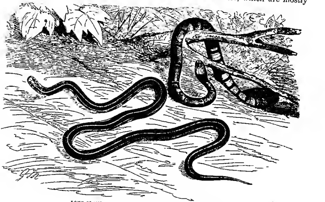
Coral Snake. The beautiful but venomous coral-snake (*Elaps corallinus*) is the best known representative of a genus which brings us to the third and last series of the great family under consideration. All the members of this front-fanged series (Proteroglypha) are characterised by having the front teeth of the hinder upper jawbone, or maxilla, grooved, and the posterior ones simple and solid. These snakes are all poisonous; and they are divided into two subfamilies, according to their habits and the conformation of the tail. In the first, or Elapine subfamily (*Elapinæ*) the tail is cylindrical; the snakes themselves being either terrestrial or arboreal in their mode of life. These Elapine snakes are distributed in larger or smaller numbers over Asia, Africa, and America, and are especially abundant in Australia, where they form by far the greater moiety of the ophidian fauna. All of them—doubtless on account of the immunity from attack conferred by their poisonous character—are remarkable for the beauty of their coloration.

The coral-snake and its allies constitute a genus well represented in the warmer regions of America, but also occurring sparingly in South Africa. They are small, although rather long and plump serpents, with the body cylindrical, the head flattened and scarcely differentiated from the neck, and the tail short. The small eye has a circular pupil, the mouth is narrow, and the jaws admit of but slight dilatation. Superiorly, the body is clothed with equal-sized, smooth scales, arranged in fifteen rows; while inferiorly the body-shields are rounded, the anal one being undivided, and the shields beneath the tail arranged in a double series. Behind the fangs, the teeth are all small. One of the handsomest members of a beautiful group is the coral-snake, which inhabits a large part of South America, and also occurs in the West Indies. Attaining a length of from 2 feet to 2¼ feet, this snake has its ground-colour a brilliant cinnabar-red, with a special lustre on the under-parts. On the body this red colour is divided into sections of equal length by broad black rings, bordered by more or less distinct greenish white margins; all the red and greenish portions showing black spots on the tips of the scales. The front of the head, as far back as the hinder end of the frontal shields, is bluish black; at the back of the parietal shields there commences a greenish white crossband, running behind the eye, and occupying the whole of the lower jaw; and after this comes a black neck-ring, followed by one of the red spaces of the body. As a rule, instead of being red, the tail has alternations of black and whitish rings, with its tip whitish. The coral-snake is generally met with in


CORAL-SNAKE (⅔ nat. size).

forests, the neighbourhood of human dwellings it strictly avoids. Somewhat slow in its movements, it is unable to climb trees; and its food consists of other snakes, lizards, insects, and centipedes.

Resplendent Adders. In Asia the place of the coral-snake and its allies is taken by a group of nearly allied species which may be collectively termed resplendent adders. From the last genus these are distinguished by the presence of a distinct groove along the whole of the front surface of the upper fangs, and also by the scales being arranged in thirteen rows. None of the teeth behind the fangs are solid, and the shields on the head (among which the loreal is wanting) are of large size. A further difference from the American genus is to be found in the presence of postfrontal bones in the skull. These adders, which are mostly



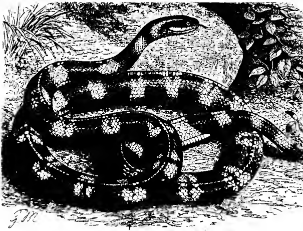
LONG-GLANDED SNAKE AND MASKED ADDER (½ nat. size).

less than 3 feet in length, are represented by seven species, spread over the Oriental region, Southern China, and Japan. The masked adder (*Callophis macclellandi*), which attains a length of 26 inches, and ranges from Nipal to the south of China, is generally reddish brown above, with regular black, light-edged transverse rings placed at equal distances from one another; the under-parts being yellowish with black crossbands or squarish spots. The resplendent adders resemble the coral-snake in the slowness of their movements, and their inability to ascend trees; their favourite resorts being hilly districts. They closely resemble the harmless snakes of the genus *Calamaria*, upon the different species of which they chiefly feed.

Long-Glanded Snakes. Closely allied to the preceding are two snakes from Burma and the Malayan region which merely differ in that the poison-glands, instead of being confined to the back part of the head, extend along each side of the body for about a third of its total length, gradually thickening till they end in front of the heart in club-shaped expansions. The heart being thrown further back in the body than ordinary, these snakes may be recognised externally by the thickening of that region. The figured species (*Adeniophis intestinalis*) is an extremely elongated and slender snake, inhabiting Burma and the Malayan Islands, and attaining a length of 2 feet. It is generally brown above with a yellowish black-edged line running down the middle of the back, and a nearly similar one on each side of the body; the under-parts being banded with yellow and black.

Craits.

Although the native name crait applies properly only to a single member (*Bungarus cæruleus*) of this genus, it may be conveniently extended to include the whole of the eight species, which range from India to the south of China, five occurring in India and Ceylon. Closely connected with the resplendent snakes by the genus *Hemibungarus*, in which a solid tooth is present behind the fangs, the craits have from one to three small solid teeth behind these; and the smooth scales are arranged in thirteen or fifteen rows, with the middle row of the back larger than the others. The head resembles that of the last genus in being imperfectly distinguished from the neck, as well as in the size and number of its shields; while the small eye has a similar round pupil. The tail is of moderate length, or short, with the shields on its lower surface arranged in either a double or single series. The banded adder (*B. fasciatus*) belongs to a group in which the shields on the lower surface of the body are very large, and broader than long; those of the tail being arranged in a single series. The species is distinguished by the presence of a distinct ridge along the back, by the obtuse extremity of the tail, and by the front temporal shield of the head being scarcely longer than



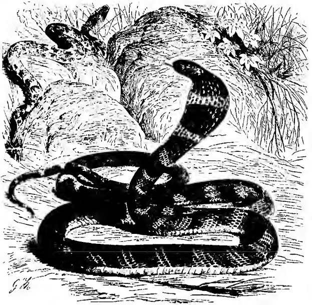
BANDED ADDER, OR RAJ-SAMP (¼ nat. size).

deep; these three features distinguish it from the blue adder or crait (*B. cæruleus*) and the nearly allied Ceylon crait (*B. ceylonicus*). The banded adder, or raj-samp (king-snake), ranges from Bengal to Java, and commonly measures about 4 feet in length, although it grows to 6 feet. In colour it is bright yellow, with black rings equal to or exceeding in length the light interspaces; while on the head a black band commences between the eyes and widens towards the nape of the neck; the tip of the muzzle being brown. The crait is of a dark, almost steel-blue black, or chocolate-brown, colour, with narrow white crossbars, streaks, or rings of white; the under surface being of a dark livid hue, or whitish or yellowish. It inhabits the whole of India, but is not so large as the raj-samp, which is probably as poisonous, though it does not come much into contact with human beings, and is, therefore, a less terrible destroyer of life. The crait frequently insinuates itself into houses, where it conceals itself in bathrooms, verandahs, cupboards, or between the bars of shutters; while an instance is on record where one was discovered coiled up beneath the pillow of a palki in which a lady had made a night's journey. Next to the cobra, the crait is credited with killing more human beings in India than any other snake.

Cobras

The name "cobra de capello," or hooded snake, was applied by the Portuguese in Ceylon to the common Indian representative of a genus of deadly serpents distinguished from the craits by their power of inflating the neck, and likewise by the scales in the middle of the back not being larger than the rest. By Europeans these snakes are now generally known by the name of cobras. Agreeing with the craits in having the fangs furnished with a complete groove on the front surface, and likewise by the presence of from one to three solid teeth behind them, the cobras have the head distinct from the neck, and covered with large shields, among which the loreal is wanting; the eye being rather small, with a round pupil. The body is cylindrical, with the smooth scales disposed in fifteen or more oblique rows; while the tail is of moderate length, with its inferior shields in either a single or a double series. The dilatation of the neck, which always takes place when they are excited and about to strike, at once serves to distinguish the cobras from all other snakes. Cobras are confined to Africa and Southern Asia, and are represented by six or seven species, two of which are found in India and a third in Java and Borneo, the others being African. Of the Indian forms, by far the most abundant is the common or true cobra (*Naia tripudians*), which is known to the natives of India as the kala nag or kala samp (black snake). Distinguished by having no large shields on the head behind the parietals, and by the whole of the shields on the under surface of the tail being arranged in a double series, this snake is a very variable species as regards coloration, some examples having a dark spectacle-like mark on the back of the hood, while others have only a single eye-like spot, and others, again, have no mark at all in this region. In regard to coloration Mr. Boulenger remarks that the hue of the upper-parts may be greyish brown or black, with or without a spectacle—or loop-shaped black light-edged marking on the neck—or with light spots or crossbands on the body; while beneath it varies from whitish, through brownish, to blackish, sometimes with black crossbars on the fore-part of the body. Occasionally attaining a length of a few inches over 6 feet, while an instance is on record where a specimen

measured upwards of 7 feet 3 i
India and Ceylon, ranging westwards throu
the east to the Malayan region, and the south of China. e other Indian .
or giant cobra (*N. bungarus*), is a larger snake, distinguished by the presence of a pair of large shields on the head behind the parietals, while the shields beneath the tail usually form only a single series. When adult, its colour is yellowish or brown,



YOUNG GIANT COBRA OR HAMADRYAD (⅓ nat. size).

with more or less distinctly marked dark crossbands; but young specimens are usually black, with yellow rings on the body and bars on the head, and in some instances there are light spots on the upper surface, and the inferior shields are whitish with black margins. In size, the giant cobra is known to measure as much as 13 feet, and probably grows larger. Fiercer than the common species, this cobra is fortunately far less abundant; its range extending from India through Burma and Siam to the Malayan region and the Philippines. Another species is the asp or Egyptian cobra (*N. haie*), which is widely spread over Africa, and presents great variations in colour. Somewhat exceeding in size the true cobra, the asp is distinguished by the sixth upper labial shield of the head much exceeding the others in length, and uniting with the temporal, so as to form a large plate, which anteriorly comes in contact with the postocular shield. In most Egyptian examples the colour of the upper-parts is uniformly straw-yellow, while the under-parts are light yellow; but there may be dark crossbands on the under surface of the region of the neck, which sometimes unite into a patch. The straw-colour may, however, shade into blackish brown and occasionally the hues may be brighter.

Habits.

Our account of the habits of these snakes will be mainly confined to the common Indian species, and since these have been specially studied by Sir J. Fayrer we shall paraphrase or quote from his writings. Although frequently seen in motion during the day, cobras are most active during the night; and they feed chiefly on small mammals, birds' eggs, frogs, fish, and even insects. The giant cobra subsists, however, almost entirely on other snakes; and the other species will occasionally rob hens' nests, swallowing the eggs whole. In captivity, cobras will live weeks and even months without tasting food of any kind or touching water. Although essentially terrestrial, they will readily enter water, in which they swim well; while they occasionally climb trees in search of food, and are often found, more especially during the rainy season, in old buildings and walls, or in wood-stacks and heaps of rubbish. It is when collected in such situations that they are most commonly trodden upon by the natives—and more frequently at night than at other times—with the well-known fatal results. These snakes lay from eighteen to twenty-five oval eggs about the size of those of a pigeon. Ascending to a height of some eight thousand feet in the Himalaya, the common cobra "is equally dreaded and fatal wherever met with; fortunately it is not naturally aggressive, unless provoked, at which times its aspect is most alarming. Raising the anterior third or more of its body, and expanding its hood, with a loud hissing, it draws back its head prepared to strike, and, when it does so, darts its head forwards, and either scratches, or seizes and imbeds its fangs in the object of attack. If the grasp be complete and the fangs imbedded in the flesh, dangerous and often fatal effects result; but if the fangs only inflict a scratch, or if the snake be weak or exhausted, the same great danger is not incurred. If the poison enter a large vein and be quickly carried into the circulation, death is very rapid; men having been known to perish from cobra-bite within half an hour. The largest and strongest as well as the smallest and weakest creatures succumb; but, fortunately, all who are bitten do not die. In the first place, some human beings as well as lower animals, have greater tolerance than others of this or of other poisons—a result, doubtless, of idiosyncrasy or varying degrees of nervous energy which enables one to resist that to which another would yield; or a wound may have been inflicted and yet but little of the poison inoculated; or, in the third place, the snake may be weak or sickly, or it may have been exhausted by recent biting, and thus have become temporarily deprived of the power of inflicting a deadly wound. But when a cobra in the full possession of its powers bites, and injects the poison into man or beast, it is almost surely fatal, and all the remedies vaunted as infallible antidotes are futile."

Death-Adders. Among the deadliest of Australian snakes is the purplish death-adder (*Pseudechis porphyriaca*), alone representing a genus characterised by the great elongation and slenderness of the cylindrical body, the sharply pointed tail, the small head, imperfectly differentiated from the neck and clothed with large shields, the smooth scales, arranged in from seventeen to twenty-three rows, the divided anal shield, and the arrangement of the shields on the under surface of the tail at first in a single, and posteriorly in a double series Behind the fangs are one or two solid teeth in the upper jaw; the pupil of the eye is round; and the neck cannot be dilated. This snake, which grows to a length of about seven feet, is very variable in coloration. Generally, however, the colour of the back varies from a shining purplish black to dark olive-brown, the under-parts being red, and the sides carmine; but the latter colours not occupying the centres of the scales, which are black, as are the hinder borders of the shields of the under surface. Generally known to the settlers by the name of the black

SHORT DEATH-ADDER, AND SPINY-TAILED DEATH-ADDER (¼ nat. size).

snake, this reptile is dreaded alike by natives and Europeans although, fortunately, it nearly always endeavours to escape when discovered. The short death-adder (*Hoplocephalus curtus*), represented in the upper figure of the illustration on p. 225, is selected as a well-known example of a second Australian genus, which includes a large number of species. Closely resembling the harmless snakes in general appearance, these death-adders are distinguished from the other members of this group by the presence in the upper jaw of a row of small, curved, solid teeth behind the fangs. The head is unsymmetrically four-sided, flattened, and rounded at the muzzle, the body massive, and the tail either moderate or short. The smooth and equal-sized scales are arranged in from fifteen to twenty-one rows, those on the middle of the back not being larger than the rest; and there is but a single row of shields on the under surface of the tail. All these species are peculiar in the group for producing living young. The figured species, which varies from 3 to 4 feet in length, has a short tail, and nineteen rows of scales. Although very variable as regards coloration, the head is generally uniform black, the body olive-colour, with broad brown or black crossbands, the hinder-part of the body and the upper surface of the tail uniformly blackish, and the whole of the under-parts light yellow. Some specimens have, however, no dark bands on the back. The spine-tailed death-adder (*Acanthophis antarcticus*), depicted in the lower figure of the illustration, represents a genus easily recognised by the horny appendage with which the tail terminates; the middle row of scales in the fore-part of the body being more or less distinctly keeled. In addition to Australia and New Guinea, this snake also inhabits the Eastern Moluccas, as well as Ceram and Amboyna. It feeds chiefly upon frogs and young birds and is regarded by Europeans as most deadly, although the natives believe that no one ever dies from a death-adder's bite.

Sea Snakes.

The sea-snakes are now considered to represent merely a subfamily (*Hydrophiinæ*) of the front-fanged Colubrines. From the preceding subfamily they are distinguished, not only by their marine habits, but likewise by their strongly compressed and oar-shaped tails, in the skeleton of which both the superior and inferior spines of the vertebræ are very strongly developed. With the exception of the broad-tailed sea-snakes, which form a kind of transition between the present and preceding subfamilies, these snakes never leave the water; and the inferior surface of the body and tail is either covered with scales similar to those on the upper-parts, or, if shields are present, they are of small size. All are very poisonous, and produce living young. Their headquarters are the coasts of the Indian Ocean and the tropical districts of the Western Pacific, their range extending from the Persian Gulf to New Guinea and Northern Australia. The parti-coloured sea-snake has, however, a more extensive distribution, ranging from the western coast of Africa to the western shores of Tropical America, and extending as far north as Japan and Mantchuria, and as far south as New Zealand. All of them have relatively small heads, jaws, and fangs; and while in some cases the body is short and thick, in others it is very thick only in the region of the tail, and elsewhere disproportionately elongated and attenuated. Always varied, the coloration is often brilliant and beautiful, and the oar-like form of the tail and hinder-part of the body is obviously an

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adaptation to an aquatic life. Living in the sea, or in tidal waters, their movements in the clear blue water are agile and elegant; but when thrown ashore, as frequently happens, the majority are helpless. Their food consists of fish and such other creatures as they can capture in the sea. In parts of the Bay of Bengal, sea-snakes are sometimes seen congregating in large shoals. The group is divided into nine genera, no less than six of which are represented in Indian waters.

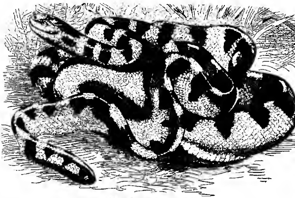
Broad-Tailed Sea-Snakes. The broad-tailed sea-snakes, of which there are three species constituting the genus *Platurus*, in general appearance closely resemble some of the craits, especially as regards the shape of the skull and the scaling of the head and body, but are distinguished by the compression and depth

BANDED SEA-SNAKE (½ nat. size).

of the tail. In the upper jaw, which is very short, there is in the maxilla of each side a pair of large grooved fangs, followed by a single very small solid tooth. The arrangement of the shields of the head is normal, each nostril being pierced in a laterally-placed nasal; the scales on the body are smooth and overlapping, and the inferior surface is covered with large shields. Of the three species, the banded sea-snake (*P. laticaudatus*) is distinguished by the absence of a keel on the lower surface of the hinder-part of the body, and also of an unpaired shield on the muzzle; the scales being arranged in nineteen rows. In colour, it is olive above and yellowish beneath, with black rings fully equal in width to the light interspaces. Attaining a length of a little over a yard, this species ranges from the Bay of Bengal and the China Sea to Polynesia. An allied but larger species

(*P. colubrinus*), with the same distribution, is distinguished by the presence of an unpaired shield on the head, and the arrangement of the scales in from twenty-one to twenty-five rows; while the third species (*P. schistorhynchus*), from the China Sea and Western Pacific, differs in having a keel along the hinder half of the lower surface of the body. That the broad-tailed sea-snakes are the direct descendants of terrestrial forms allied to the kraits, is proved by their retention of large inferior shields, and by their habits. Not only are these snakes frequently found at some distance from water, but in Sumatra a specimen was captured nearly a day's march inland.

Parti-Coloured Sea-Snake. In common with all the other members of the subfamily, the parti-coloured sea-snake (*Hydrus platyurus*) has the nostrils placed on the upper surface of the muzzle; and the under surface of the body and tail in this species are scaled like the rest, although in some of the genera traces of enlarged shields still persist. In the skull, the maxilla is considerably longer than the transverse bone, and carries a pair of short fangs, followed, after an interval, by seven or eight solid teeth; the muzzle is elongated; the head-shields are large, the nasals being in contact with one another; and the scales on the relatively short body hexagonal in form and with their edges in apposition. This snake attains a length of a yard; and in colour is either yellowish with symmetrical black transverse bands or spots, or uniformly black above, and yellow, with or without black spots below; the yellow tail being ornamented with either black spots or bars. It is the sole representative of its genus, and has a wider distribution than any other member of the group, ranging over the whole of the Indian Ocean and the tropical and subtropical portions of the Pacific. The typical sea-snakes, forming the large genus *Hydrophis*, differ in having from seven



BLACK-BANDED SEA-SNAKE (⅔ nat. size).

to eighteen solid teeth in the maxilla, by the longer body, on the anterior part of which the scales are imbricating, and by the presence of more or less distinct small shields on the lower surface.

Black-Banded Sea-Snake. The black-banded sea-snake (*Distira cyanocincta*) may be taken as an example of another large genus differing from the preceding in that the fangs are followed in the maxilla by from four to ten solid teeth with their front surface grooved. In these snakes the body is more or less elongated, and generally has the scales on its front portion slightly overlapping, while the under surface carries small shields. The figured species, which grows to a length of 6 feet, is of a greenish olive above, with black transverse bars or rings, which are sometimes connected by a longitudinal stripe on the under surface. This snake ranges from the Persian Gulf to the Malay Archipelago and Japan, and is one of the most abundant in the Indian seas.

There are several points in which the sea-snakes differ from their land cousins as regards habits, in addition to those already noticed. In the first place, the skin is changed piecemeal, instead of entire; the casting taking place at very frequent intervals. Moreover, the tongue is very short, and only the extreme tips of its two extremities are exserted through small notches on either side of the rostral shield of the head, which is prolonged downwards so as to close the mouth. When, however, these snakes are cast ashore and almost blinded by the unaccustomed light, the tongue is used in the ordinary manner as a feeler.

THE VIPERS.

Family *VIPERIDÆ.*

Omitting mention of the small and unimportant family of harmless snakes known as blunt-heads (*Amblycephalidæ*), represented by two Oriental and two tropical American genera, we pass to the viper family, which includes the whole of the remaining members of the suborder. The distinction between a colubrine and viperine snake is that in the latter the maxillæ or hinder upper jaw-bones are capable of being erected in a vertical plane at right angles to the transverse bones, while in form they are short and thick, and they always carry a single pair of large tubular fangs. All vipers are poisonous, and, so far as known, produce living young; while they are more or less nocturnal and terrestrial in their habits, although a few ascend trees. The thick body, the flat and often triangular head, the short and stumpy tail, the reduction of the maxillary teeth to a single pair of fangs, and the vertical pupil of the eye, are all features distinguishing vipers as a whole from the poisonous colubrines; but, as already mentioned, it is frequently necessary to examine the structure of the skull itself before any particular snake can be assigned to its proper serial position. That the vipers form a highly specialised group is self-evident; and Mr. Boulenger believes them to be descended from the hind-fanged colubrines. The family is divided into two groups, namely, the typical vipers of the Old World, which attain their maximum development in Africa, and the American and Asiatic pit-vipers.

True Vipers. Our first representatives of the Old World vipers (*Viperinæ*) are the true vipers, which form a genus with some twenty species, ranging over Africa (exclusive of Madagascar), Europe, and a large portion of Asia, one of them reaching India. In common with the other members of the subfamily, they have no pit in the loreal shield of the head, while they are specially distinguished by the upper surface of the head being covered either with scales or small shields, and by the keeled scales of the body running in straight longitudinal rows, which vary in number from twenty-one to thirty-eight; and likewise by the double row of shields beneath the tail.

Common Viper. The common viper (*Vipera berus*), which is happily the only British poisonous snake, is one of the smallest representatives of the genus, and is distinguished by the mixture of scales and shields on the head (three of the latter being larger than the rest), and the general presence of only a single row of scales between the eye and the upper labial shields beneath. In colour and markings the common viper is extremely variable; but as a rule a dark zigzag stripe runs down the whole length of the middle of the back. With regard to coloration, in some specimens the ground-colour is nearly olive, in others a deep rich brown, and in others a dirty brownish yellow; while a mark between the eyes, a spot on each side of the hinder part of the head, the above-mentioned zigzag line formed of confluent quadrangular spots on the back, and a row of small irregular triangular spots on each side of the body, are of a darker hue than the ground-colour, and are frequently nearly black. In some examples the underparts are lead-colour, with lighter or darker spots, while in others they are almost wholly black. Bell records a specimen in which the ground-colour was nearly white and the markings black; and in one variety the ground-colour is brick-red, with ferruginous markings, while in a second the under-parts acquire a more or less marked blue tinge; and in a third the whole skin, with the exception of that beneath the jaw and throat is black, the usual markings being visible in certain lights. The average length of the common viper is about 10 inches. Its geographical distribution is greater than that of any other European snake, extending from Portugal eastwards to the Island of Saghalien, while northwards it reaches to the Arctic Circle, and southwards to Central Spain.

Southern Viper. In South-Western Europe the common viper is replaced or accompanied by a closely-allied form which may be called the southern viper (*V. aspis*), regarded by some writers as a distinct species, and by others as a mere variety. As it was doubtless to this snake that the Latin term *Vipera* was applied, German writers restrict the name viper to the southern form, and use the term *Kreuzotter* for the common viper. In the latter the front of the upper surface of the head is covered with three distinct small shields, but in the southern form it is clothed only with smooth or slightly ridged scales, among which seldom more than a single polygonal roundish one can be regarded as representing a frontal shield; moreover, instead of the single row of small scales generally separating the eye of the common viper from the upper labial shields, the southern form always has two such rows. There is likewise a difference in the shape of the muzzle in the two forms. The southern viper may be considered characteristic of the Mediterranean countries, occurring in North

A FAMILY OF VIPERS.

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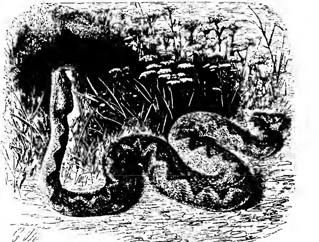
Africa as well as in Europe. It is noteworthy that in the borderland of the distributional areas of the two forms, such as Northern Spain and Italy, it is difficult to say to which of the two any specimen may belong.

More numerous in Scotland than the ringed snake, but, like it, unknown in Ireland, the common viper generally frequents heaths, dry woods, and sandy banks. Although its bite produces severe effects, it is seldom, unless the sufferer be very young or in ill-health, that death ensues. During the winter months, vipers generally hibernate in small parties for the sake of mutual warmth, several being often found twined together in a torpid condition.



LONG-NOSED, OR SAND-VIPER (½ nat. size).

Long-Nosed Viper. Another well-known poisonous European snake is the long-nosed, or sand-viper (*V. ammodytes*), easily recognised by the presence of a soft horny appendage at the end of the nose, covered with scales and not unlike a conical wart in appearance. It is also distinguished from the common viper by the absence of any large shield, except the supraoculars, on the top of the head; although in coloration the two species are very similar. In size it is the largest European representative of the group, attaining a length in some rare instances of just over a yard. The sand-viper ranges from Italy to Armenia. In Carinthia it is the commonest of snakes, while in the Tyrol it is local but abundant in the south of Hungary and Dalmatia. Mainly nocturnal, it is much more commonly found in hilly than in level districts, ascending in the mountains to a height of between three thousand and four thousand feet. Except during the pairing-season, when it is found in couples, it is a solitary creature, subsisting on other snakes, mice, voles, birds, and lizards.

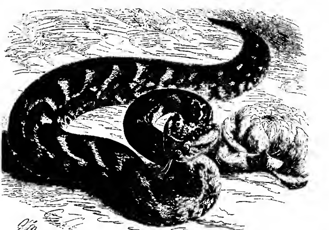
Russell's Viper

As being one of the deadliest of Indian snakes, we may take as our next example of the genus the beautiful Russell's viper (*V. russelli*) of India, Ceylon, Burma, and Siam. From the other viper inhabiting Kashmir, this species may be distinguished by having the rostral shield of the head as long as broad, and the scales on the body arranged in from twenty-seven to thirty-one rows. Sometimes known as the chain-viper, this snake attains a length of 4 feet. Its ground-colour is pale brown, with three longitudinal series of black light-edged rings, sometimes replaced by faint dark spots; the lower-parts being yellowish white, either with or without small crescentic black spots. In young specimens, as shown in our illustration, the black rings on the upper-parts surround dark reddish brown spots, which in the middle series are in contact with one another. Sir J. Fayrer regards this snake as being, next to the cobra, the most dangerous in India, stating that fowls bitten by it sometimes expire in less than a minute. "It is nocturnal in its habits, is sluggish, and does not readily strike unless irritated, when it bites with great fury; it hisses fiercely and strikes with vigour. Its long movable fangs are very prominent objects, and with them it is capable of inflicting deep as well as poisoned wounds. When disturbed

RUSSELL'S VIPER (⅕ nat. size).

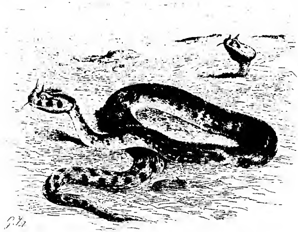
its loud hissing is calculated to warn those who approach it, and it does not appear to cause many human deaths, although it may be that its misdeeds are sometimes ascribed to the cobra. This viper is said to frequently kill cattle while grazing, by biting them about the nose or mouth. In proof of its sluggish nature, there is a well-authenticated tale of a young person having picked one up, and, mistaking it for an innocent snake, carried it home; its true character being only discovered when it bit a dog."

Puff-Adder. In Africa the place of Russell's viper is taken by the dreaded puff-adder (*V. arietans*), which occasionally attains a length of 6 feet. It is the only member of the genus in which the unusually small nostrils open upwards near the extremity of the muzzle; and it is further distinguished by having a supranasal shield, covered, like the region of the brow, with upright horny scales or spines. In appearance most hideous and repulsive, this snake has the large and flattened head triangular in shape, very broad and blunt at the muzzle, and sharply defined from the body, the latter being thick and almost triangular in section. Both head and body are covered with keeled overlapping scales, differing from one another only in size, and arranged on the body in from thirty-one to thirty-three longitudinal rows, and forming three or four series between the eyes and the upper labials. The coloration and marking vary to a certain extent individually; but there is a great change in the brightness of the tints immediately after the changing of the skin. The puff-adder is spread over



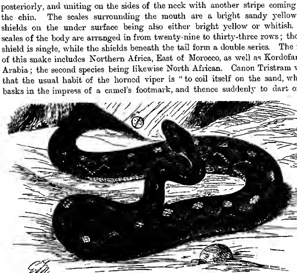
THE PUFF-ADDER (¼ nat. size).

nearly the whole of Africa, and is everywhere dreaded from its deadly nature. Inhabiting dry and sandy places, it derives its name from its habit, when angry or alarmed, of drawing in a full breath and causing the body to swell visibly. Then the air is allowed to escape gradually, producing as it does so a prolonged sighing or blowing sound which continues till the lungs are emptied, this process being repeated so long as the provocation lasts. Usually this reptile lies half-hidden in the sand with its head fully exposed, and when approached merely rises without attempting to escape, and so virulent is its bite that even horses have been known to die within a few hours after being struck. The poison is used by the bushmen for their arrows, to the tips of which it is made to adhere by being mingled with the viscid juice of the amaryllis.



HORNED VIPERS IN THE SAND (½ nat. size).

Horned Vipers. Next to the southern viper, or asp, no serpent was more feared by the ancients than the Egyptian cerastes, or horned viper (*Cerastes cornutus*). As a genus, the two species are characterised by the small crescentic nostrils situated on the sides of the muzzle, the presence in the male, and sometimes in the female, of a pair of scale-covered, horn-like processes above the eyes, the arrangement of the scales of the body in oblique rows, and the short keels on the scales, which stop short of their tips. The common horned viper may be immediately recognised as an inhabitant of desert places from the general sombre and mottled tone of its coloration, which is so admirably adapted to such surroundings. Usually attaining a length of about 2 feet, it is of a light brownish ground-colour, more or less tinged with yellow, upon which are six longitudinal rows of circular or quadrangular dark markings, increasing in size from the middle of the back towards the sides. Beneath the eyes runs a dark brown band, while the middle of the head is marked by a light brownish yellow streak, dividing posteriorly, and uniting on the sides of the neck with another stripe coming from the chin. The scales surrounding the mouth are a bright sandy yellow, the shields on the under surface being also either bright yellow or whitish. The scales of the body are arranged in from twenty-nine to thirty-three rows; the anal shield is single, while the shields beneath the tail form a double series. The range of this snake includes Northern Africa, East of Morocco, as well as Kordofan and Arabia; the second species being likewise North African. Canon Tristram writes that the usual habit of the horned viper is "to coil itself on the sand, where it basks in the impress of a camel's footmark, and thence suddenly to dart out on any passing animal. So great is the terror which its sight inspires in horses, that I have known mine, when I was riding in the Sahara, suddenly start and rear, trembling and perspiring in every limb, and no persuasion would induce him to proceed. I was quite unable to account for his terror, until I noticed a cerastes coiled up in a depression two or three paces in front, with its basilisk eyes steadily fixed on us, and no doubt preparing for a spring as the horse passed." According to Bruce, this snake, when about to attack, moves rapidly forward with a sideways motion, unlike that of any other serpent. Attacking when quite unprovoked, the horned viper is more dreaded than any other North African snake, men frequently dying from its bite within half an hour. Its food consists of desert-haunting rodents, together with lizards, and perhaps birds.



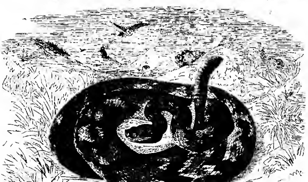
THE EJA, OR DESERT SAW-VIPER (⅔ nat. size).

Desert Saw-Vipers. While agreeing with the horned vipers in having the lateral body-scales arranged in oblique rows, the present genus may be distinguished by [illegible] having but a single series of shields beneath the tail, as well as by the absence of horns. The upper surface of the head is covered with scales, and the keeled scales of the body form from twenty-five to thirty-five rows. The common desert saw-viper, or, as it is called in Egypt, efa (*Echis carinata*), attains a length of about 2 feet, and has the keels on the lateral scales of the body strongly serrated. In colour it varies from pale buff to greyish, reddish, or pale brown on the upper-parts, with three series of whitish spots edged with dark brown, in addition to which there may be a dark brown zigzag band along each side, while the head is ornamented with a cross or arrowhead mark, and the under-parts are whitish, either with or without brown dots. This species inhabits the desert regions of Northern Africa, South-Western Asia, and India, being replaced in Arabia and Palestine by *E. colorata*.

The most remarkable peculiarity of this viper (which, however, it may possess in common with the horned vipers, since the scales of the latter have a similar structure) is its power of making a curious, prolonged, almost hissing sound, produced by rubbing the folds of the sides of the body one against another, when the serrated lateral scales grate together. That this is the true cause of the sound may be proved by twisting the body of a dead specimen, and thus causing friction between the scales. Sir J. Fayrer writes that this species is a very fierce and vicious viper; it throws itself into an attitude of defence and offence, coiled up like a spring, rustling its carinated scales as it moves one fold of the body against another. It is aggressive, and does not wait to be attacked before darting its head and body at its enemy, the mouth wide open, and the long fangs vibrating, thus presenting a most menacing appearance. It is very poisonous, and there can be little doubt that it destroys many human lives, as men are much more exposed to contact with this species than with Russell's viper.

Rattle Snakes. The dreaded rattle-snakes of the New World are our first representatives of the subfamily of pit-vipers (*Crotalinæ*), which are common to Asia and America, and are characterised by the presence between the nostril and the eye of a deep pit in each loreal shield, the physiological significance of which is still unknown. All have triangular broad heads, and short thick bodies. The Asiatic representatives of the group are less deadly serpents than their American relatives; while the only vestige of the rattle of the latter to be found in the former is a small horny spine at the end of the tail of one species. Many of the Indian species are arboreal in their habits; their coloration assimilating to that of the foliage and boughs among which they dwell. As regards their geographical distribution, pit-vipers present a curious similarity to bears and deer, and since they are most abundant in the Oriental region, and also more numerous in North than in South America, Mr. Wallace is of opinion that the group originated in the Indo-Chinese countries, and thence spread north-eastwards to North America, and so onward to the southern half of the New World, which area, having been the last to receive the group, has not had time, in spite of its extreme fitness for reptilian life, to allow it to attain its full development.

The rattle-snakes are sufficiently distinguished from their allies by the jointed horny appendage at the end of the tail from which they derive their name. In the young rattle-snake the tail terminates in a somewhat nail-like "button," which in a perfect rattle remains at the tip, the various rings, which may reach to twenty or more in number, being gradually interpolated between this and the scaly portion of the tail. More or less symmetrical in form, the rattle is composed of hollow, horny rings, somewhat like quill in substance, which are interlocked with one another, and are yet so elastic as to allow of a considerable amount of motion between them. The various rings do not appear to be formed with any regularity, sometimes several being added in a single year, while at other seasons but one is developed; neither does there seem to be any relation between the growth of the rattle and the changing of the skin. That very large rattles must, however, belong to old snakes, is obvious; and that this is really the case is shown by the circumstance that at the present day rattles with twenty rings are very



COMMON RATTLE-SNAKE (¼ nat. size).

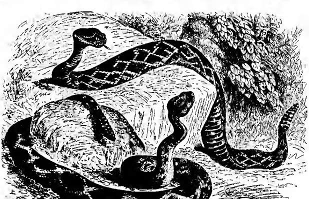
seldom met with, since with the advance of cultivation it is only rarely that these noxious reptiles are suffered to attain their full age. The body is thick, and, for poisonous snakes, somewhat long; and the poison-glands attain very large dimensions.

Common Rattle-Snake. Since the rattle-snakes are extremely variable in coloration, reliance has to a great extent to be placed on the arrangement of the shields covering the fore-part of the head in the discrimination of the species. In the common rattle-snake (*Crotalus durissus*) of North America, the distinctive character is the presence of only two pairs of large shields between the large supraocular and rostral shields; these paired shields being separated by a series of small ones in the middle line. Of these shields, behind the large triangular rostral comes the four-sided anterior pair, representing the anterior frontals, while to each of the latter further back joins a larger oval shield which must be regarded as a lateral remnant of the hinder frontal. The space between the two last-named shields is occupied by a series of small shields, of which the front ones are the largest: and between the supraocular shields commence the long keeled scales covering the body, where they are arranged in from twenty-five to twenty-seven longitudinal rows. The ground-colour of the upper surface is a dull greyish brown, upon which are two rows of large, irregular spots, which may unite into zigzag crossbands, and are gradually lost on the dark tail, the under-parts being yellowish white, marked with small black dots. Generally about 4½ feet in length, this species may grow to 6 feet.

Diamond Rattle-Snake. In the Southern United States the commonest member of the genus is the diamond rattle-snake (*C. adamanteus*), represented in the upper figure of the accompanying illustration, which is not only the most beautiful, but likewise the largest species, adult females (which in this group are always larger than the males), not unfrequently measuring 6 feet in length. From the common rattle-snake it may be distinguished by the large and narrow head, on which the shields are but slightly developed, the presence of three pairs of shields between the rostral and supraocular on the top of the muzzle, by the scales of the body being always arranged in twenty-seven rows, and also by the coloration. The small rostral shield is markedly triangular, the slightly developed frontal has a roundish pentagonal form, and the great supraocular shield a distinctly overhanging edge. After shedding, the new skin is of a beautiful greenish, or occasionally golden-brown, ground-colour: upon this is a triple lozenge-shaped chain-pattern on each side of the back, the golden yellow lines of which stand out in marked contrast to the dark diamonds of the ground-colour. A blackish brown band runs from the muzzle through each eye to the corner of the mouth; and the top of the head is either uniformly coloured, or ornamented with irregular markings.

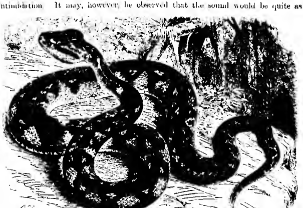
South American Rattle Snakes. Of the six species of the genus, four are confined to North America, and only one is found to the southward of the Isthmus of Panama. The latter species (*C. horridus*), which is represented in the lower figure of our illustration, approaches the common species as regards the arrangement of the shields on the head, while in coloration it is like the diamond rattle-snake. From the former it may be distinguished by the circumstance that the two pairs of shields between the rostral and the supraocular have no small shields between them, so that they come in contact with one another in the middle line; while from the latter the larger size of the lozenges on the body, and the presence in each of a light-coloured centre will serve as a sufficient distinction, in addition to the different arrangement of the head-shields.

Habits. In noticing the habits of these snakes our remarks will chiefly relate to the North American species. As we have already said, rattle-snakes chiefly frequent dry and sandy localities, more especially when they are covered with bushes; but we have to add that in North America they frequently take up their abode in the burrows of the prairie-marmot. Formerly it was thought that the snakes and marmots lived together in harmony, but it is now ascertained that the former prey on the young of the latter. The general food of rattle-snakes consists of small mammals, birds, lizards, and frogs, the latter being especial favourites; but mammals as large as a mink have occasionally been taken from them. The most extraordinary peculiarity connected with the common species is its habit in the colder regions of North America of collecting in enormous numbers for the winter sleep. In some districts the snakes used to assemble in hundreds, or even thousands, from all sides to sleep in the ancestral den, some of them, it is said, travelling distances of twenty or even thirty miles. Huddled together in masses for the sake of warmth, the serpents passed the winter in a state of more or less complete torpor, until the returning warmth of spring once more started them to spread over the country. When rattle-snakes were abundant, annual or biennial hunts used to take place at these dens; the fat of the slaughtered reptiles being used as a valuable supply of oil. Catlin tells us how, when a boy, he once assisted at one of these hunts at a place known as Rattle-snake Den, whence the snakes used to come forth on to a certain ledge of rock in swarms. At one time, he says, there was a knot of them "like a huge mat wound and twisted and interlocked together, with all their heads like scores of hydras standing up from the mass," into which he fired with a shot-gun. Between five hundred and six hundred were killed with clubs and other weapons, but hundreds more escaped to the den. Fortunately one large one was taken alive, and was made the means of destroying the rest, a powder-horn with a slow fuse being applied to its tail, and the reptile allowed to crawl back to the cave, where a loud explosion soon told the tale of the destruction that had taken place.



DIAMOND AND SOUTH AMERICAN RATTLE-SNAKES ($\frac{1}{10}$ nat. size).

The most interesting point in connection with rattle-snakes is the use to which the appendage from which they derive their name is put,—for use it must surely have. The old view was that it was intended to warn creatures preyed on by these reptiles of the approach of their enemy; but in regard to this supposition, Darwin well observes that "I would almost as soon believe that the cat curls the end of its tail when preparing to spring in order to warn the doomed mouse. It is a much more probable view that the rattle-snake uses its rattle, the cobra expands its frill, and the puff-adder swells while hissing so loudly and harshly, in order to alarm the many birds and beasts which are known to attack even the most venomous species. Snakes act on the same principle which makes a hen ruffle her feathers and expand her wings when a dog approaches her chickens." In this passage the writer commits himself to the view that the rattle is an instrument of intimidation. It may, however, be observed that the sound would be quite as



THE BUSHMASTER (⅙ nat. size).

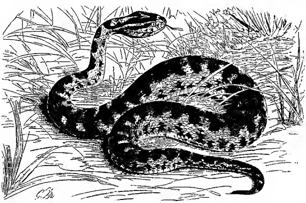
likely to attract enemies as to repel them. Moreover, it is now a well-ascertained fact that rattle-snakes do not possess the power of hissing; and as that faculty seems more closely connected with fear than with any other emotion, it would be quite reasonable to suppose that the rattle stands in place of the hiss. Another feature in the controversy is the circumstance that the sound of the rattle of one snake causes all its kindred within hearing to sound their own; and the organ therefore probably serves as a means of communication. What is known as the "dinner-bell" theory, that is, that a rattle-snake attracts insects like grasshoppers and cicadas within striking distance by the resemblance of the sound of its rattle to their own stridulating utterances, has been pretty clearly disproved; while if it required a further quietus, the circumstance that these reptiles do not appear to prey habitually upon insects would be sufficient. On the whole, while admitting that fear has probably some share in the matter, it seems better to suspend our judgment before definitely committing ourselves to any one particular view. That rattle-snakes are some of the most deadly of all venomous serpents may be freely admitted; and it seems that we must almost concede that they possess the mysterious power of "fascinating" their victims before striking. Moreover, the assertions as to the power possessed by vipers of swallowing their young are equally numerous and well-authenticated in the case of the serpents under consideration.

The Bushmaster. The formidable South American snake (*Lachesis muta*) known to the Dutch settlers of Guiana as the bushmaster, but by the Brazilians termed the surukuku, differs from the rattle-snakes by the presence of a distinct keel-like ridge down the back, and, in place of a rattle, having the under surface of the tip of the tail covered with from ten to twelve transverse rows of small, spiny, sharp scales, while the extremity terminates in a spine. This snake attains a length of from 9 to 12 feet, and has the ground-colour of the upper-parts reddish yellow, upon which is a longitudinal row of large blackish brown lozenges, each having two light spots on either side of the middle line; while the under-parts are yellowish white, with a porcellanous glaze. The large size and enormous poison-fangs of the bushmaster render it one of the most formidable of the pit-vipers; its bite being apparently fatal to human beings in a few hours. Fortunately it is far from common, and inhabits only the secluded portions of the primeval forest, where it lies coiled up on the ground. Unlike most snakes, when disturbed it makes no attempt to flee, but strikes with the rapidity of lightning at the disturber of its slumbers.

Halys Vipers. These snakes have the upper surface of most, or all, of the front of the head covered with large shields; the body is rather long and clothed with from seventeen to twenty-seven rows of keeled scales; and the very short tail has its lower shields arranged in either a double or single series, some species having a small spine at the extremity, which is regarded as a rudimentary rattle. The genus is common to Asia and North and Central America, some half-score of species being known, two of which are found in India. One species ranges as far east as the Urals, where it just enters the confines of Europe. In habits they are all terrestrial.

Himalayan Halys. Of the Indian species, in both of which at least the majority of the shields on the lower surface of the tail are arranged in two rows, the Himalayan halys (*Ancistrodon himalayanus*) is distinguished by having two pairs of large shields on the muzzle, the extremity of which is but little turned upwards. In colour it is brown, with black spots or transverse bands, while sometimes a light festooned stripe runs down the back; from the eye to the angle of the mouth runs a black streak edged with white; and the under-parts are either dark brown, or variegated with black and white. This snake, which grows to nearly a yard in length, is abundant in the North-Western Himalaya, at elevations of between five thousand and eight thousand feet, although it sometimes ascends considerably higher. The carawila (*A. hypnale*), of Ceylon and Western India, is a much smaller species, not exceeding 20 inches in length, and characterised by the extremity of the upturned muzzle being covered with small scales.

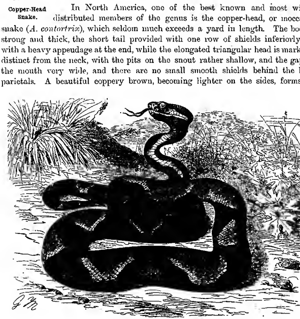
Siberian Halys. Somewhat superior in size to the common viper, this species (*A. halys*) may be recognised by the small portion of the head that is covered with shields, and also in that each shield, or pair of shields, overlaps with its hinder edge the shield immediately behind it, thus producing a more or less marked imbrication of the whole of the head-shields. Another characteristic is to be found in the small size of the anterior frontal shields, which together have a crescentic shape and a somewhat saddle-shaped upper surface. The head is very distinctly defined from the compressed neck, the body being rather long, of a rounded triangular form in the middle, and covered with twenty-three rows of triangular scales; the very short tail, which is much thinner than the hinder-part of the body, is conical, and armed at the extremity with a forked horny appendage. The ground-colour of the middle of the back is a dark brownish yellow grey, while that of the under-parts is a yellowish white, with more or less well-defined black spots on the hinder shields. The yellow ground of the labial shields of the head has chestnut-brown markings; and the crown of the head bears a large quadrangular blotch, forming an interrupted transverse band on the frontal shields, and a temporal band running from the hinder border of the eye to the angle of the mouth and the side of the neck. Somewhat similar markings ornament the back, and are more or less clearly margined with yellow. Along the whole length of the back and the ridge of the tail are a number of yellowish or yellowish white black-edged irregular blotches or crossbands; and on the sides are two rows of blackish brown spots with white edges, which frequently run one into another, the first dark spot on the neck differing from the rest by its horse-shoe form. The distributional area of this snake extends eastwards from the Volga to the Yenesei. In Europe the halys



SIBERIAN HALYS VIPER (½ nat. size).

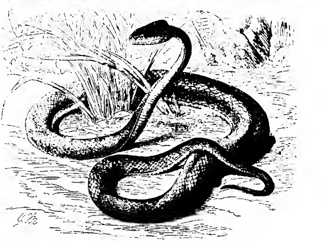
viper inhabits the steppes between the Volga and the Urals; but its true home is Central Asia.

Copper-Head Snake. In North America, one of the best known and most widely distributed members of the genus is the copper-head, or moccasin-snake (*A. contortrix*), which seldom much exceeds a yard in length. The body is strong and thick, the short tail provided with one row of shields inferiorly and with a heavy appeudage at the end, while the elongated triangular head is markedly distinct from the neck, with the pits on the snout rather shallow, and the gape of the mouth very wide, and there are no small smooth shields behind the large parietals. A beautiful coppery brown, becoming lighter on the sides, forms the ground-colour of the upper-parts; upon which some sixteen reddish brown dark-edged bands, becoming wider on the flanks, have given rise to the name of moccasin-snake. On the under-parts the shields are copper-red, marked on the sides with large polygonal or rounded alternating dusky spots. The head is generally lighter coloured than the body, and marked by a broad stripe running from the snout along the side to the angle of the mouth. The distribution of the copper-head extends from the 45th parallel of north latitude to the extreme south of the Eastern United States. Its favourite haunts are damp situations, more especially shady meadows covered with tall grass; and its food consists of mice, birds, and probably frogs. From its abundance and comparatively rapid movements, as well as from its lacking the warning sound of the rattle, the copper-head is even more dreaded than the rattle-snake.



COPPER-HEAD, OR MOCCASIN-SNAKE (⅔ nat. size).

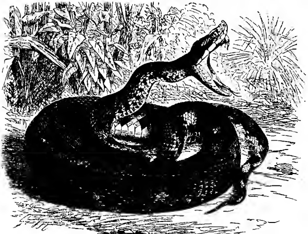
Water Viper. Another well known North American representative of the **genus** that must come in for a brief share of attention is the **water-viper (*A. piscivorus*)**, which inhabits marshes, rivers, and lakes, and attains **a length of** nearly five feet. From the preceding species it may be distinguished **by the** presence of two small smooth supplemental shields behind the parietals, **and of** numerous small scales between the hinder frontal and temporal shields. The **colour** is very variable, but in the majority of specimens, on a shining greenish **grey** ground there are a larger or smaller number of dark bands somewhat **similar to** those of the copper-head. Always found in the neighbourhood of water, **this** snake extends southwards from North Carolina over the whole of North **America**



CLIMBING PIT-VIPER (½ nat. size).

and westwards as far as the Rocky Mountains. Feeding chiefly upon fish and frogs it will also devour all animals that may happen to fall into the water and are not too large for its maw; while in the rice-fields it is the dread of the negroes. Not only is the water-viper feared by man, but it is shunned by all animals dwelling in or near water.

Typical Pit-Vipers. Under this title may be included the members of the largest genus of the subfamily, which is likewise common to Tropical America and Asia, and is the last group of snakes that we have space to mention. These pit-vipers are long-bodied snakes, characterised by the whole of the upper surface of the triangular head being covered with scales instead of shields; the tail, which is frequently prehensile, ending in a sharp point, and having either one or two rows of shields on its lower surface. In all the Asiatic species there are two rows of these subcaudal shields, and it is only in a few of the New World forms that they are reduced to a single series. The number of longitudinal rows of scales on the body is very variable in the different species, ranging from as few as thirteen to as many as thirty-one. In Asia these snakes range from India to the South of China and the Liu-Kiu Islands; and while some species are terrestrial and normally coloured, others are arboreal, and in the greenish tints assimilate to the colour of their surroundings. The climbing tree-viper (*Trimeresurus gramineus*) belongs to a group of four allied Indian and Burmese species, characterised by their prehensile tails and the arrangement of the scales on the body in from thirteen to twenty-three rows; the figured species usually having twenty-one rows of scales, while there are from seven to thirteen scales in a transverse series on the head between the supraoculars; the temporal scales are smooth, and the shields on the lower surface of the tail vary in number from fifty-three to seventy-five. Attaining a length of 2½ feet, this snake usually has the upper-parts bright green, although in some specimens they may be yellowish, greyish, or purplish brown, while they may or may not be marked with black, brown, or reddish spots. Generally there is a light-coloured or reddish streak along the outer row of scales, and the end of the tail is frequently red or yellow; the under-parts being green, yellow, or whitish. Ranging from Bengal to the Malayan region, this species is thoroughly arboreal in



RAT-TAILED PIT-VIPER ($\frac{1}{10}$ nat. size).

its habits. Stoliczka states that he found these snakes very common about the limestone hills near Moulmein, where they are exactly of the same green colour as the foliage amongst which they hide themselves. He saw small specimens very often on low umbelliferous plants growing about a couple of feet high. One of the snakes had its tail wound below round the stem of the flower on the top of which it was basking. All were very sluggish, and did not make the slightest attempt to escape when approached, and even allowed themselves to be removed from the top of the plant. Neither did they offer to bite, unless when pressed to the ground with a stick; but when thoroughly aroused they turned round and bit furiously. The rat-tailed pit-viper, or fer-de-lance (*T. lanceolatus*) is one of several American species with nonprehensile pointed tails, whose habits are terrestrial. Reaching a length of nearly 7 feet, with a body as thick as a man's arm, this snake is very variable in coloration, the ground-colour of the upper-parts being generally a reddish yellow-brown. The distinctive markings take the form of a black stripe, which is but seldom absent, running from the eye to the neck, and of two rows of irregular dark crossbands on the body. In some specimens the sides of the body are, however, of a bright red. The form and arrangement of the scales on the head, the presence of seven upper labial shields, and the arrangement of the body scales in not more than twenty-nine rows, together with the uniformly coloured under surface of the body, serve to distinguish the species from its congeners. This snake is an inhabitant of the Antilles and Central America. During the daytime it lies curled up in repose within the middle of the coils of the body, ready to dart out with the rapidity of lightning on the approach of an enemy.

Jararaca

The mainland of South America is the home of two closely allied terrestrial representatives of the genus, respectively known as the jararaca (*T. jararaca*) and the labaria (*T. atrox*), which are exceedingly difficult to distinguish from one another. The former, which ranges from Amazonia southwards to San Paulo and westwards to Ecuador and Peru, has eight or nine upper labial shields on the snout, and from twenty-five to twenty-seven rows of scales on the body; the general colour of the upper parts being grey or greyish brown, with small dark brown crossbands, bordered by darker edges; while the under-parts are grey, with two or four irregular longitudinal rows of whitish or yellowish spots. The labaria differs in having only seven upper labials, as well as in certain details of coloration, the back showing dark lozenges alternating with X-shaped markings, while the under-parts are darker, with sometimes two rows of white spots, and from the eye to the corner of the mouth runs a broader dark brown stripe. Inhabiting Eastern Brazil, this species extends as far north as Guiana, while its southward range is less than that of the jararaca.

Writing of the latter, Bates states that in Brazil it is far more dreaded than the jaguar or the alligator. "The individual seen by Lino lay coiled up at the foot of a tree, and was scarcely distinguishable, on account of the colours of its body being assimilated to those of the fallen leaves. Its hideous, flat, triangular head, connected with the body by a thin neck, was reared and turned towards us, Frazao killed it with a charge of shot, shattering it completely, and destroying its value as a specimen. In conversing on the subject of jararaca as we walked onwards, every one of the party was ready to swear that this snake attacks man without provocation, leaping towards him from a considerable distance when he approaches. I met, in the course of my daily rambles through the woods, many jararacas, and once or twice very narrowly escaped treading on them, but never saw them attempt to spring. On some subjects the testimony of the natives of a wild country is utterly worthless. The bite of the jararacas is generally fatal."

EXTINCT GROUPS OF SCALED REPTILES.

A brief reference may be made to two groups of extinct reptiles from the rocks of the Secondary epoch, which must be included in the order Squamata.

Long-Necked Lizards. The first of these groups is represented by a small snake-lizard, from the English Chalk, described under the name of *Dolichosaurus*, and forming a suborder (Dolichosauria) by itself. Whereas ordinary lizards have not more than nine vertebræ in the neck, this strange reptile has upwards of from fifteen to seventeen, while its hind-limbs are characterised by having the whole of the five metatarsal bones of the foot well developed, and its whole structure reveals a very generalised type of organisation. The vertebræ have additional articulations like those of snakes. It is probable that these reptiles form the ancestral group from which the other suborders of scaled reptiles have originated.

Cretaceous Sea-Serpents. A still more remarkable group of the order is formed by certain carnivorous marine reptiles from the Cretaceous rocks, many of which attained gigantic dimensions, and may not inappropriately be designated extinct sea-serpents. Commonly known as Mosasauroids, on account of the first described genus (*Mosasaurus*), having been found on the banks of the Meuse, they form a suborder technically known as the Pythonomorpha. They all had a much elongated body, and a skull approximating in structure to that of the monitors among existing lizards, the nasal and premaxillary bones being welded together, and the quadrate very loosely attached to the skull. Teeth were present on some of the bones of the palate, as well as on the margin of the jaws; those of the latter series being large, sharply pointed, and attached by expanded bases. The bones of the shoulder-girdle and pelvis were more or less imperfectly developed; and the limbs were modified into paddles or flippers, with the toes enclosed in a common skin, and devoid of claws. There were either nine or ten vertebræ in the neck; and whereas, in some cases, the vertebræ resembled those of snakes, in other instances they lacked the additional articulations distinguishing the latter. It will be unnecessary to particularise the various genera of these reptiles, but it may be mentioned that while some of the better-known forms have been described as *Mosasaurus*, others have received the names of *Liodon* and *Clidastes*. They appear to have inhabited the Cretaceous seas of all parts of the world, having been obtained from regions as far apart as England, New Zealand, and Argentina; and while some attained a length of between 25 and 30 feet, others were not more than 8 or 10. Then, again, while in some cases the jaws were armed with powerful teeth to their extremities, other forms had a long, toothless beak.

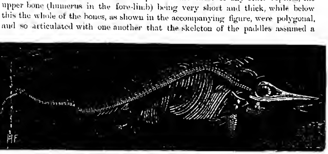
CHAPTER VI.

The Remaining Groups of Reptiles,—Orders Ichthyopterygia, Rhynchocephalia, and Anomodontia.

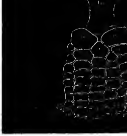
Of the three orders remaining for consideration, two are completely extinct, and not known from deposits of later date than those of the Secondary period, while the third is represented at the present day only by a single species from New Zealand, although in former geological epochs it appears to have been abundant. The first of the three for consideration is the group of

Fish-Lizards,—Order Ichthyopterygia.

More or less familiar to all from the beautifully preserved skeletons obtained from the Lias of England and the Continent, specimens of which are exhibited in almost every museum, the Fish-lizards, or Ichthyosaurs, were large marine reptiles, with the naked body thick and whale-like, the neck extremely short, and the limbs modified into paddles differing from those of all other members of the class in the structure of their skeleton. The skull is produced into a long snout, generally furnished with a full series of sharp teeth, and mainly formed in the upper jaw by the premaxillary, or front jawbones; and the nostrils are consequently placed close to the eyes, the latter, like those of birds, being provided with a ring of movable plates. Superiorly the skull has a hole or foramen, in the parietal bones; while posteriorly the upper and lower arches are connected behind the socket of the eye by a bone known as the supratemporal, so that this portion of the skull is completely roofed over, as we shall see to be the case in the Labyrinthodont Amphibians. Then, again, the quadrate-bone, with which the lower jaw articulates, is firmly united to the adjacent elements of the skull; while in the general relations of this bone and the bones of the palate there is a marked agreement with the beaked reptiles. The teeth are confined to the edges of the jaws where they are implanted in distinct sockets; and generally have conical and fluted crowns, although more rarely they are compressed and smooth, with sharp cutting edges at the front and back. The back-bone presents a nearly similar structure, the vertebræ, as shown in the figure on p. 6, being short discs, which may be either deeply cupped or nearly flat at the two ends. In the body and neck these vertebræ carry a pair of tubercles on each side for the articulation of the forked ends of the ribs; but in the tail there is but one such tubercle, the ribs being single-headed. Moreover, the vertebræ are further remarkable for the absence of any body union between the body or centrum (the part represented in the figure), and the arch enclosing the spinal marrow, so that these two portions are always found detached. The bones of the shoulder-girdle much resemble those of lizards, the collar-bones being well-developed, and the T-shaped interclavicle resting on the lower surface of these and the metacoracoids. The limbs are quite unlike those of any other reptiles, the upper bone (humerus in the fore-limb) being very short and thick, while below this the whole of the bones, as shown in the accompanying figure, were polygonal, and so articulated with one another that the skeleton of the paddles assumed a kind of pavement-like or mosaic structure. In most kinds the front paddles were much larger than the hinder-pair; and whereas, in some cases, two longitudinal series of bones originate from the bone marked *i* in the accompanying figure, thus producing a very broad type of paddle, in other forms (as shown in the skeleton in the figure above), only a single series articulated with that bone, and the whole paddle was consequently much narrower. Specimens like the one figured here show that while the soft parts of the paddle extended but a short distance in advance of the front edge of the bones, on the hinder-side they terminated in a wide fringe, thus forming a structure admirably adapted for swimming. Other examples indicate that the back of these reptiles was furnished with an upright triangular fin somewhat like that of a porpoise, behind which were a number of small finlets, while the extremity of the tail was expanded into a horizontal fin, comparable to the flukes of a whale. Many of these reptiles attained a length of from 30 to 40 feet; and they flourished throughout the whole of the Secondary period, that is to say, from the epoch of the Trias, or Red Sandstone, to that of the



SKELETON OF FISH-LIZARD, SHOWING YOUNG ONE WITHIN THE CAVITY OF THE RIBS ($\frac{1}{12}$ nat. size)
(From Gaudry.)



PART OF THE FORE-PADDLE OF A FISH-LIZARD.

hu, bone of upper arm; *r.u*, bones of fore arm; the other letters indicate the bones of the wrist, below which are the bones of the fingers.

Chalk most or all of the forms from the first-named deposits being of a more generalised type than those of later date.

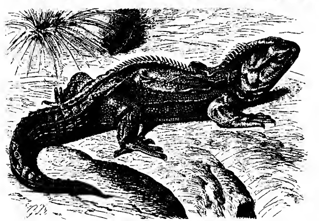
In external appearance the fish-lizards must have presented a marked resemblance to whales, the place of which they seem to have filled in the old seas. Like these animals, they were obliged to come periodically to the surface of the water for the purpose of breathing; and they were likewise carnivorous, as is attested not only by the conformation of their teeth, but likewise by the petrified remains of their prey. Occasionally specimens are met with, in which entire skeletons of one or more young individuals of the same species are preserved within the cavity of the ribs, thus proving that in these reptiles the eggs were hatched within the body of the females, and the offspring produced in a living condition.

THE BEAKED LIZARDS.

Order RHYNCHOCEPHALIA.

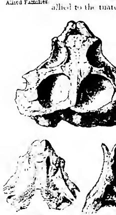
The tuatera, which seems to be confined to the small islands off the north-east of New Zealand, is not only the most remarkable of all existing reptiles to which the term lizard can be applied, but is the sole living representative of a distinct family, as well as of an entire order; and the difference between it and an ordinary lizard immeasurably exceeds that by which the latter is separated from a serpent. As an order, the beaked reptiles may be provisionally characterised as follows. Externally most of these reptiles appear to have been more or less lizard-like; and, as in their living representative, the body was probably covered above with small granular scales intermingled with tubercles. The skull differs essentially from that of lizards in having the quadrate-bone immovably fixed by the upper end to the adjacent bones; and likewise by having both an upper and a lower temporal arch. The hind portion of the palate is formed by the union of the pterygoid bones, which generally at least, extend forwards to meet the vomers, and thus divide the palatines; while the anterior upper jawbones, or premaxillæ, remain separate from each other. The teeth are not implanted in distinct sockets and are usually welded to the summits of the jaws. In the trunk the ribs articulate to the vertebræ by single heads, and may have hook-like processes similar to those of birds; while on the lower surface of the body so-called abdominal ribs are always developed, forming a shield composed of a number of segments, and comparable to the plastron of the tortoises. The vertebræ may be either hollowed at both articular ends, or the hinder surface may be cupped and the front one ball-like. That the beaked reptiles form a very primitive group is clear, not only from their structure, but from their antiquity; representatives of the order occurring in the Permian strata, immediately overlying the Carboniferous or coal-bearing rocks. While some of these early forms appear to connect the order very closely with the Sauropterygians, others indicate an equally close relationship with the under-mentioned Anomodonts.

The Tuatera. The single existing representative of the order (*Sphenodon punctatus*) forms a family (*Sphenodontidæ*) by itself, and likewise is the representative of a distinct suborder (Rhynchocephalia Vera), characterised by each segment of the shield on the lower surface of the body being formed of only three elements, of which the middle one is chevron-shaped, and likewise by the fifth metatarsal bone of the hind-foot being reduced in length and thickened in the same manner as in lizards. The group is further characterised by the double nostrils, the union of the two branches of the lower jaw by cartilage, and the deeply hollowed articular surfaces of the vertebræ. From its extinct allies the family is distinguished by having a perforation on each side of the lower extremity of the humerus, or upper bone of the fore-limb, by the presence of hook-like processes to the ribs, as well as of so-called intercentra, or additional segments between the bodies of the vertebræ; and likewise by the beak-like premaxillary bones carrying a pair of somewhat chisel-like teeth, and the presence of only a single row of teeth on the palate, which are separated by a groove from the row affixed to the edge of the upper jaw. Into this groove is received the teeth and upper edge of the lower jaw, which in very old individuals becomes as hard and polished as the teeth themselves; the latter being more or less completely worn away in extreme old age. On the upper surface of the skull is a large vacuity, or foramen, in the parietal bones. In external appearance the tuatera is lizard-like, the body being slightly and the long tail strongly compressed; while the limbs carry five toes, all furnished with claws, and connected at their bases by webs. There is no external opening to the ear, and the large eye has the pupil vertical. On the upper-parts the creature is clothed with small granular scales intermixed with tubercles; and a crest of spine-like scales runs from the hinder-part of the head down the middle of the back, continued in a smaller degree of


NEW ZEALAND TUATERA (⅓ nat. size).

development down the tail, while inferiorly there are large squarish scales arranged in transverse rows. Attaining a length of about 20 inches, the tuatera is olive or bluish in ground-colour, upon which are small yellowish dots, while the lobes of the crest on the neck and back are likewise of the latter colour. The perforation in the parietal bones of the skull just referred to covers a rudimentary eye, which although now functionless was probably a working organ in the ancestors of the Vertebrates. In the young tuatera this pineal eye can be seen through the translucent skin, but in the adult this skin becomes opaque.

Allied Families. In the Jurassic rocks of Europe there occur remains of reptiles allied to the tuatera, but constituting a distinct family (*Homœosauridæ*) typically represented by the genus *Homœosaurus*. These have no tusk-like teeth in the front of the jaws, and the lower end of the humerus has a perforation only on its inner side, and there are no intercentra between the vertebræ of the back, and no hook-like processes to the ribs. A third family (*Rhynchosauridæ*) is typified by the genus *Rhynchosaurus*, from the Trias or New Red Sandstone of England, and is characterised by the beak being toothless and probably sheathed in horn; the palate having two or more longitudinal rows of teeth separated by a groove. From the preceding families these reptiles differ by having only a single aperture to the nostrils, and by the bony union of the two branches of the lower jaw; while the articular surfaces of the vertebræ are nearly flat. Moreover, there is no vacuity in the middle of the top of the skull. In the typical genus there is a single row of teeth on the inner side of the groove on the palate, but in *Hyperodapedon*, there were numerous rows, as is shown in the illustration. The extremity of the beak in each jaw formed two curved tusk-like processes, which diverged in the lower one.



SKULL OF THE *Hyperodapedon* (⅓ nat. size).

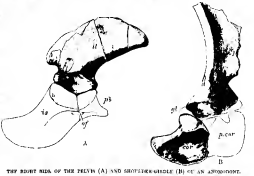
The upper figure shows the upper aspect; the lower one on the left the palate, and the right lower one the under surface of the front of the lower jaw.

Oldest Types. The Permian rocks of Europe yield remains of genera such as *Protorosaurus* and *Palæohatteria*, differing markedly from the foregoing and constituting a second suborder (Proterosauria), characterised by the complex nature of the bones forming the shield on the lower surface of the body, by the fifth metatarsal bone of the hind-foot being of an ordinary type, and likewise by the lower bones of the pelvis being expanded into large flattened plates, instead of comparatively narrow. The last feature allies the group to the earlier Sauropterygians. In the genus first named the vertebræ of the neck have cup-shaped articular surfaces behind and balls in front, and there are no intercentra between the vertebræ of the back, but in the other the articular surfaces of the vertebræ are slightly cupped at each end throughout the series, and intercentra are present.

THE ANOMODONTS, OR MAMMAL-LIKE REPTILES.

Order ANOMODONTIA.

The last order of Reptiles, which is entirely extinct and confined to the Triassic and Permian epochs, is of especial interest to the evolutionist as being nearly allied to the ancestral stock from which Mammals have originated, and also equally closely related to certain extinct Amphibians noticed in the sequel, which were themselves evidently not far removed from the type whence sprang both Reptiles and Mammals. It should be observed, however, that these Anomodonts show the nearest relationship to the Egg-laying Mammals, and until we know the true affinity of the latter to the other members of the same class, it is of course impossible to attempt to define the genealogy more exactly. The Anomodonts are the only reptiles which agree with the Egg-laying Mammals in having three distinct bones on each side of the true shoulder-girdle: that is to say, a blade-bone, or scapula, above, and a coracoid and metacoracoid below. Then the pelvis is very mammal-like, not only in that its three elements are united, but likewise in the small size of the vacuity, or foramen (*of*) between the pubis and ischium. It will also be seen from the two figures here given how close is the resemblance between the pelvis and shoulder-girdle of these reptiles, each having one bone above and two below. Even still more marked is the similarity between the upper arm-bone or humerus of the Anomodonts and that of the Egg-laying Mammals; each having a perforation on the inner border of the lower end, whereas in those existing reptiles which possess such a perforation (with the exception of the tuatera, where there is one on each side), it is situated on the outer border. As a rule, the Anomodonts further resemble Mammals in the absence of abdominal ribs; and there are important similarities in the structure of the skull.



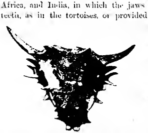
THE RIGHT SIDE OF THE PELVIS (A) AND SHOULDER-GIRDLE (B) OF AN ANOMODONT.

il, haunch-bone, or ilium; *is*, ischium; *pb*, pubis; *of*, foramen between ischium and pubis; *sc*, blade bone, or scapula; *p.cor*, coracoid; *cor*, metacoracoid: *gl*, cavity for head of upper arm-bone, or humerus.

Anomodonts are met with in the Triassic rocks, and are represented by at least four well-marked subordinal types. In the first group, known as Mammal-toothed (Theriodont) Reptiles, the teeth, as exemplified in the figure of the skull of the African galesaur, are differentiated into incisors, tusks, and cheek-teeth; the latter frequently having three cusps ranged in a longitudinal series. Whether, however, this marked mammalian type of dentition is indicative of genetic affinity with Mammals, may be open to doubt, as it is quite as likely to be due to parallelism in development. Another modification is presented by the Dicynodonts of England, Africa, and India, in which the jaws formed a horny beak, either destitute of teeth, as in the tortoises, or provided with a huge pair of tusks in the upper jaw; some of these reptiles being of gigantic size. A third group, known as Pavement-toothed, or Placodont Reptiles, which should probably be included in the order, are characterised by the presence of broad, flattened teeth on the palate and jaws, as shown in the figure on p. 5; the skull being very short and more or less triangular, with the double nostrils situated near the extremity of the muzzle, some distance in advance of the sockets of the eyes, which occupy a nearly central position. In all these forms, the skull has large temporal fossæ in the hinder part of the upper surface; but in the Wall-toothed or Pariasaurian Anomodonts, as shown in the cut, the hinder part of the skull was roofed over by bone, in the manner characterising the Labyrinthodont Amphibians, to which these reptiles were allied, a peculiar sculpturing of the surface of the skull being another point of resemblance. In the species of which the skull is figured, a number of spines surmounted the head; but these were wanting in the African pariasaur, which was a gigantic creature, with a somewhat frog-like head, an apology for a tail, and powerful short limbs, in which the toes were armed with long claws.

UPPER SURFACE OF THE SKULL OF A PAVEMENT-TOOTHED ANOMODONT (½ nat. size).

SKULL AND TEETH OF GALESAUR



UPPER SURFACE OF THE SKULL OF A WALL-TOOTHED ANOMODONT (½ nat. size).

FIRE-BELLIED FROGS (nat. size).

AMPHIBIANS.

CHAPTER I.

GENERAL CHARACTERISTICS,—Class **Amphibia**.

FROGS AND TOADS,—Order ECAUDATA.

IN popular estimation frogs and toads, together with their near relatives the newts and salamanders, are regarded as Reptiles, but they are really very different, and constitute a class by themselves, being in many respects intermediate between Reptiles and Fishes. From the mode of life of its members the very appropriate name of Amphibians has been proposed for the class, and is the one which should be adopted, although the term Batrachians, which more properly applies to frogs and toads alone, is not unfrequently used in the same sense. Agreeing with the higher Vertebrates in the structure of their limbs, which are divided into the same number of segments as in Mammals and Reptiles, and supported by corresponding bones, existing Amphibians are distinguished from Reptiles by the absence of any ossification in the basioccipital region of the lower surface of the hinder-part of the skull, in consequence of which the latter is articulated to the first vertebra by means of two condyles formed exclusively by the exoccipital bones. A further important point of distinction is afforded by the absence in the embryo of those membranous structures known as the amnion and allantois. Moreover, the great majority of Amphibians pass through a metamorphosis, or rather a series of metamorphoses, commencing their existence immediately after leaving the egg in a larval condition during which they breathe the air contained in water by means of gills, while in the adult state they breathe atmospheric air by means of lungs. Varying much in external form, these animals nearly always have the body covered with a soft naked skin; but in a few instances among existing forms scales are embedded in the skin, and most of the extinct forms had a well-developed armour of scales and bony scutes. In some forms a longitudinal fin is developed down the middle of the back and tail, but this is always soft, and lacks the supporting spinous bones characterising that appendage in fishes. In passing through a metamorphosis, Amphibians are more like the inferior groups of animals than the higher Vertebrates; and while in the earlier stages of their existence, during which they breathe by gills, they may be regarded as very closely allied to Fishes, in the adult state they come much nearer to Reptiles. The extinct Labyrinthodonts, which are themselves not very widely removed from fishes, and have the basioccipital bone ossified, serve to connect other members of the class with the Anomodont and Beaked Reptiles. And it may be mentioned here that while in Mammals the skull has continued to be supported by the two condyles of the Amphibians, in the Reptiles the basioccipital bone has developed an intermediate condyle filling up the gap between the two exoccipital condyles, and thus forms a single tripartite condyle like that of the tortoises. Frequently, as in the crocodiles, the lateral elements have tended more or less completely to disappear, thus leaving a condyle formed almost entirely by the basioccipital.

Skin

As already said, the skin of most existing Amphibians is soft and naked; it is invested with a colourless epidermis, which is periodically shed entire, while the deeper layer is often coloured with blotches or streaks of yellow, red, brown, or black. Other colours, however, such as green and blue, are produced by pigment-cells, which generally make their appearance under special conditions of warmth and moisture. As a rule, the colour of Amphibians varies to a great extent with the nature of their surroundings, as is well exemplified in the case of the frog, which changes its hue according to the nature of its habitat; while the tree-frogs harmonise with the foliage among which they dwell. It is, however, very remarkable that in Costa Rica a certain toad simulates to an extraordinary degree the coloration of the snakes—both poisonous and harmless—of the same country; while in North Sumatra Amphibians of various groups are spotted with carmine-red. In all Amphibians the skin is furnished with glands secreting a more or less milk-like fluid, these glands being generally distributed all over the body, although sometimes they are confined to the sides of the neck behind the eyes. In many toads and land-salamanders some of the larger glands appear as prominent warts, pierced with large pores. The viscid, milky fluid secreted by these glands is exuded during excitement, and is endued with more or less poisonous properties, being intended to serve as a means of defence. Although some degree of irritation of the skin may be produced by handling some of the species in which these poisonous properties are most developed, the stories of toads or salamanders spitting venom are, it is almost needless to observe, pure fabrications. When introduced into the circulation, batrachian venom acts, however, as a powerful poison, influencing the heart and central nervous system;

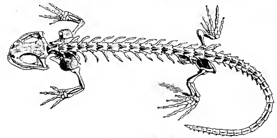
and the secretion of a South American species is employed by the Indians to poison spears and arrows used in killing monkeys.

BULL-FROGS DISPORTING.

In the economy of Amphibians the naked skin and its glands play a most important part, since none of them drink, in the proper sense of the word, but imbibe moisture through the pores of their integument. Moisture is, indeed, essential to their existence, and if they be confined in a dry atmosphere they soon perish. It is true that frogs may be seen basking in the sun's rays and apparently enjoying the warmth as much as lizards, but they only do this in the neighbourhood of water, to which they retire when necessary. Such members of the class as inhabit dry localities, are mostly nocturnal, avoiding sunshine, and wandering abroad when they can obtain moisture from dew.

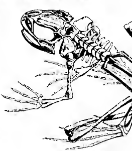
Skeleton

The skeleton of the Amphibians presents many peculiarities, and in some forms has numerous fish-like characters. For instance, in certain of the forms with permanent gills the vertebræ are scarcely distinguishable from those of fishes; whereas in the true newts they have a rounded knob at the front of the body and a cup at the hinder extremity, and are closely articulated with one another. In the long-tailed groups the number of vertebræ is considerable: but in the frogs and toads those of the back are reduced to seven or eight, the hinder-end of the backbone terminating in a long style, extending between the greatly produced extremities of the haunch-bones, or ilia, which articulate with the lateral processes of the sacral vertebræ. The transverse processes of all the vertebræ are well-developed, and in some cases very long; and they take the place of ribs, which, at the most, are represented by some small rudiments. In consequence of this absence of ribs, Amphibians are unable to breathe in the ordinary way by alternate expansion and contraction of the cavity of the chest; and they, so to speak, swallow air, taking in a large gulp, and then closing the mouth. In addition to the peculiarities connected with its condyles and the basioccipital region, the skull is distinguished by its flattened, broad, and more or less semicircular form; the sockets for the eyes being generally large and ill-defined. In front of the condyles the under surface of the middle of the skull is overlain by a large parasphenoid bone, which is frequently dagger-shaped; this bone being generally but slightly, if at all, developed in the higher Vertebrates, although very large in Fishes. The lower jaw, which articulates with the skull by the intervention of a quadrate-bone, is composed of at least two pieces on each side, and may



SKELETON OF SALAMANDER.

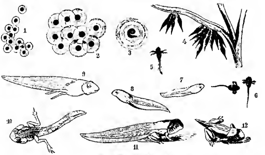
contain more elements. The palatines and vomer, and more rarely the parasphenoid, may be armed with teeth, like the upper jaw; but in the frogs and toads the lower jaw is very generally toothless. In all cases the teeth are small, simple, and pointed, being adapted for holding, and not for masticating. The shoulder-girdle, which is largely cartilaginous, is placed very close to the head, and comprises the usual elements. Each scapula, or shoulder-blade, has an upper cartilaginous portion, extending inwards nearly to the middle line of the back; while in the frogs each metacoracoid has an inward cartilaginous expansion, which may either meet or overlap its fellow, and is of much importance in classification. In advance of the metacoracoids is another pair of transverse bars commonly known as the precoracoids; while in front of these is a single median rod termed the omosternum; the proper sternum, or breast-bone, occupying a similar position behind the metacoracoids. In the fore-limb the radius and ulna may be united, and the wrist cartilaginous; the number of toes among living forms never exceeding four, and being sometimes reduced to three. More variation exists in the hind-foot, the number of toes in the long-tailed forms ranging from two to four, whereas in the frogs and toads it is always five. Only in a few frogs and newts are the toes furnished with claw-like nails; in the greater number of forms these being naked, although often connected by webs, and sometimes carrying adhesive discs on the lower surface.



SKELETON OF FROG.

Soft Parts. In all Amphibians the brain is of a very low type, its component portions lying in a line one behind the other, without overlapping. All possess the three chief organs of sense, although in some instances the eyes may be very minute and covered with an opaque skin. In frogs and toads the eye is large and very highly developed; generally possessing two lids, of which the lower one is larger and thinner than the upper, and more or less transparent. Greater variation exists in the structure of the ear, which is simplest in the tailed forms. The nose opens externally in a pair of nostrils situated near the muzzle, and by another pair of apertures into the mouth: the latter character distinguishing Amphibians from the majority of Fishes. The tongue, which acts only in the very slightest degree as an organ of taste, and is wanting in one group of frogs, is generally well-developed and thick, filling the whole space between the jaws, and being capable of a large amount of motion; it differs essentially from that of the higher Vertebrates in that it is affixed to the inner side of the front of the lower jaw, with its tip pointing down the throat.

Development. All Amphibians lay eggs, which are generally although not invariably deposited in fresh water, and fertilised as they are extruded from the female. As a rule, these eggs, which much resemble those of fish, are small, very numerous, and connected together by mucilage, forming either a string or a jelly-like mass in which the dark yolks are very conspicuous. Some of the tree-frogs, however, lay large eggs, within which the larvæ undergo the whole of such transformation as takes place; and in one genus, instead of the usual gills, a temporary breathing-organ is developed on the tail. A land-frog in the Solomon Islands also lays large eggs, like small marbles, which are deposited in the crevices of rocks, and from which emerge fully-developed frogs. The eggs, with certain exceptions, are deposited in water, where they are hatched by the heat of the sun; and it appears that the dark colour of the yolk is for the purpose of absorbing as much solar heat as possible. Such eggs as are laid during the late spring and summer are less darkly coloured, and have thinner coats, than those deposited in the early part of the spring; and while the former are placed on the ground at the bottom of the water, the latter float on the surface; the reason of this difference being that in the early part of the year the lower strata of water are too cold to admit of the development of the ova. In ordinary cases, when the larva has reached a certain stage, it bursts the investing membranes of the egg, and comes into the world adapted for an aquatic life, and always possessing a long compressed tail composed of zigzag-shaped masses of muscles, similar to those of fishes. The first process is the sprouting forth of branching external gills from the sides of the neck, which in the larvæ of the frogs and toads are subsequently replaced by internal gills, but in the long-tailed forms persist for a longer period. After the disappearance of the external gills, the water is expelled from the gill-chamber by one or two tubes, generally discharging by a single orifice, which may be situated either on the lower surface of the body, or on the left side. As soon as the external gills have made their appearance, development is concentrated on the tail and the absorption



DEVELOPMENT OF THE FROG.

1, Eggs when first laid; 2, Eggs at a later stage; 3, Egg containing embryo; 4, Newly-hatched larvæ; 5, 6, Larvæ with external gills; 7–12, Later stages in the development of larvæ.

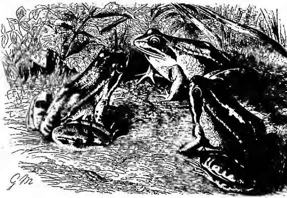
of the remainder of the yolk. The vertical fin-like expansions of the tail rapidly increase, and the body becomes relatively smaller and more slender; while the limbs begin to make their appearance as buds, although the date of development of the front and hind-pair varies in different groups. In the newts, the front pair of limbs are the first to appear, in the frogs the reverse is the case. In the latter the hind-limbs appear some considerable time before the front pair, the fish-like tail persisting till the sprouting of these, when the change from a herbivorous fish-like animal to one carnivorous and reptiliform begins. The jaws are at first invested with horny teeth, and subsequently with horny sheaths which eventually disappear; while the tail gradually diminishes in size, and finally is lost. It may be observed that no vertebræ are developed in the frog's tail, and that the long spine in which the backbone of the adult terminates is an outgrowth from the hindmost vertebra. Not less remarkable is the shortening of the intestinal canal, as the creature changes its herbivorous for carnivorous habits. To trace in detail the development of the soft parts would greatly exceed our limits of space. We may mention, however, that in one group of Tailed Amphibians the external gills of some individuals may be retained permanently, while in others of the same species they are cast at an early period. Then, again, the number of these gills is by no means constant, for in the Cingalese cæcilian and the salamander there are three pairs of these organs, in the tadpoles of some frogs there are two, and in others, as well as in one genus of cæcilians, there are only a single pair.

Distribution Geologically the Amphibians are a very ancient group, their oldest representatives occurring in the Carboniferous and Permian rocks of Europe and North America. All these ancient representatives of the class belong, however, to the group of Labyrinthodonts, which survived till the period of the Trias, and are structurally very different from the modern forms, approximating in certain respects to fishes. Indeed, since no Amphibians have hitherto been discovered between the Trias and the Wealden, or lower Cretaceous, rocks of Belgium, we are quite unable to assert that the modern representatives of the class are the direct descendants of the Labyrinthodonts. Commencing in the Belgian Wealden, the newts and salamanders occur throughout the greater part of the Tertiary rocks; but the frogs and toads are first known in North America from Eocene beds, while in Europe they are not met with before the Oligocene.

At the present time Amphibians are distributed over all parts of the world except the polar regions; although they are more dependent upon the presence of water and warmth than any of the preceding classes of Vertebrates. They are, accordingly, most abundant in the tropical and subtropical regions; and as none of them are marine in their habits, even a narrow arm of the sea is generally sufficient to limit their habitat. When they occur on islands, it is probable either that their eggs have been carried by birds, or that there has been a comparatively recent separation from the mainland. In absolutely desert districts Amphibians are unknown; while in countries where there is a long dry season, followed by a period of rains, they are in the habit of becoming torpid during the former; the length of the sleep in one Javan species being upwards of five months. In cold climates all the members of the class become torpid during the winter.

As regards their general distribution, Amphibians closely resemble fresh-water fish, and differ widely from lizards. Indeed, from an Amphibian point of view, the globe may be divided into two great regions, namely, a northern one characterised by the abundance of newts and salamanders, and the absence of cæcilians; and a southern one distinguished by the want of the former and the presence of the latter group.

Habits. In their mode of life, it is probable that very few Amphibians are diurnal; most of the terrestrial forms making their appearance abroad with the first shades of evening, and retiring to their hiding-places at dawn. In wet or cloudy weather frogs and toads—especially in South America—frequently appear in great numbers during the day; and both these groups are in the habit of making night hideous with their croakings. Although in all cases the adults are carnivorous, the larvæ subsist more or less exclusively on vegetable substances, some confining themselves to that kind of diet, while others also consume animalcules and other minute creatures.


MOOR FROGS (nat. size).

Characteristics of Frogs and Toads. The frogs and toads are distinguished from their allies by the presence of four limbs and the absence of a tail in the adult state; the latter feature giving origin to the name Ecaudata, by which the order to which they belong is scientifically designated. They all have short and frequently thick bodies, in which the backbone comprises, at most, only eight vertebræ in advance of the sacrum; those behind the latter being fused into a long rod-like bone, as shown in the figure of the skeleton on p. 261. In the fore-limb, as shown in the same figure, the bones of the fore-arm (radius and ulna) are completely fused together; and the same is the case with regard to the tibia and fibula in the hind-leg. Moreover, the hind-limb obtains a kind of additional segment, owing to the elongation of the calcaneum and astragalus in the ankle-joint, which form a pair of long bones lying parallel to one another. As a rule, frogs and toads undergo a lengthened larval period, the "tadpoles," as shown in the figure on p. 262, having a globular head and body, a fish-like tail, external or internal gills, and no limbs in the first stages of their existence. The hind-limbs are the first to appear, and after the front pair are developed the tail is gradually absorbed, upon which the young for the first time leave the water. Represented by about a thousand species, frogs and toads have a worldwide distribution, although more abundant in tropical and subtropical than in temperate regions, and being especially numerous in India and South America; and it is not a little remarkable that some of the largest forms are inhabitants of islands. From the nocturnal habits of the adults it is frequently difficult to find out whether in any locality these reptiles are abundant or the reverse; but in the spring this may generally be ascertained by observing the tadpoles in the rivers and ponds, since all of these show specific differences, to the full as well marked as those in the adult.

THE TYPICAL FROGS.

Family *RANIDÆ.*

The typical frogs, together with four other families, constitute a suborder (Firmisternia), characterised by the presence of a tongue, and by the firm union of the two metacoracoid bones of the chest by means of a single cartilage uniting their free edges. From the other members of the group, the typical frogs are distinguished as a family by the presence of teeth in the upper jaw, and by the transverse processes of the sacral vertebra being either cylindrical, or but very slightly dilated at their extremities. These characters are sufficient to distinguish the typical frogs from the other families of the suborder; but it may be added that the vertebræ are cupped in front and hollowed behind; while there are no ribs; and the terminal style of the backbone is articulated to the sacrum by two condyles. The terminal joints of the toes may be either simple or pointed, T-shaped, Y-shaped, or even claw-like; the species in which these joints are thus expanded having the soft parts similarly expanded and flattened. For a long time it was considered that the shape of the tips of the toes was connected with the mode of life of their owners; and although this is so to a great extent, it is now ascertained that several of the species in which the toes are somewhat expanded are as aquatic as those in which they are pointed, and species presenting both modifications are included within one and the same genus. The typical frogs are divided into twenty genera, only two of which are noticed in this work.

Water-Frogs. Under the general title of water-frogs may be conveniently included all the members (some hundred and forty in number), of the genus *Rana*, to which belongs the common English frog. The distinctive characters of these frogs are to be found in the horizontal pupil of the eye; the more or less deeply notched and free tongue; the presence of teeth on the vomerine bones of the palate; the absence of webs in the toes of the fore-feet, and their presence in those of the hind-limb; and the separation of the outer metatarsal bones of the hind-foot by a web, the extremities of the fingers being simple or expanded.

With the exception of the southern part of South America (where the whole family is unrepresented), Australia, and New Zealand, these frogs have a worldwide distribution. Although the greater majority of the species are probably aquatic during the breeding-season, at other times great diversity of habit is displayed by the different representatives of the genus, some being aquatic, others terrestrial, and others, again, burrowing, or even more or less arboreal. The existence of burrowing habits is indicated by the great development of a tubercle on the inner side of the metatarsus, which in one Indian species (*Rana breviceps*) has a sharp edge, and is used in a shovel-like manner to excavate the burrow. Such burrowing species are further characterised by the shortness of the hind-limbs, and thus assume a more or less toad-like appearance. Large discs at the ends of the toes usually, on the other hand, are indicative of arboreal habits; although, as already said, smaller discs are met with in certain purely aquatic species.

European Frogs. Selecting some of the European representatives of the genus for special mention, we may first notice the edible frog (*R. esculenta*), characterised by the pointed tips of the toes, the smooth under surface of the body, the presence of a broad glandular fold along the sides, and the marbling of the thighs. Exceedingly variable in coloration, this frog generally has the upper-parts olive or bronzy brown, more or less spotted or marbled with dark brown or black; there are generally three light stripes along the back, while the sides of the head and ground-colour of the flanks are sometimes green; the marbling on the thighs occupying their hinder surfaces, and being black in colour. The males are specially characterised by the presence of a globular sac, connected with the production of the croaking, on each side of the head, opening by a slit behind the angle of the mouth. Inhabiting Europe, Asia as far west as Japan, and North-Western Africa, the edible frog is common in England, the dark race occurring in the fens of Cambridgeshire, and the green variety in Norfolk. The use of the flesh as food probably led to the introduction of this species into Cambridgeshire by the monks; while the Norfolk colony was imported between 1837 and 1842. From this species the common English frog (*R. temporia*) is readily distinguished by the incomplete webbing of the hind-feet, and the presence of a dark temporal spot extending from the eye to the shoulder, as well as by the absence of external vocal sacs in the males. Moreover, if the skulls of these two species be compared, it will be found that while in the edible frog the teeth on the vomers do not extend behind the line of the apertures of the posterior nostrils, they do so to a small extent in the present species. In colour the upper-parts of the common frog are greyish or yellowish brown, more or less spotted with dark brown or black; the temporal spot being always dark, and a light line running from below the eye to its extremity; while the sides of the body are profusely spotted, the limbs transversely barred, and a larger or smaller number of spots are present on the under-parts. This species is spread over Europe and Northern and Temperate Asia. Closely allied is the moor-frog (*R. arvalis*), of Eastern Europe and Western Asia, represented in the illustration on p. 264, which may be distinguished by the tubercle on the inner metatarsal being compressed instead of blunt, and by the pointed, in place of obtuse, muzzle. The coloration is very similar to that of the common species, but there is sometimes (as in the right-hand figure of the illustration), a light stripe bordered by two black ones down the middle of the back, while the under-parts are uniform. A third European species is the agile frog (*R. agilis*), which belongs to a group distinguished by the greater length of the hind-limbs; the whole form being slender, and the muzzle pointed. Its general colour is greyish brown, with dark spots: the temporal spot being dark and distinct, with a light line running from its extremity to the snout, while the hind-limbs are regularly barred, and the under-parts unspotted. Two other European species, the one (*R. iberica*) from Spain and Portugal, and the other (*R. latastei*) from the neighbourhood of Milan, differ by the spotted lower surface of the body. Even the tadpoles of the whole of these more or less nearly allied species present differences by which they can be distinguished from one another.

AGILE FROGS (nat. size).

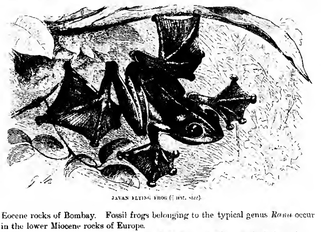
The common frog, whose habits may be taken as typical of the allied members of the genus, is found in most parts of Europe, where there is a sufficiency of moisture and shelter for its existence; the presence of water being essential during the breeding-season. All are probably familiar with the manner in which a frog swallows air; but it is perhaps less generally known that if the mouth of one of these creatures be kept forcibly open, death must inevitably ensue, owing to the impossibility of breathing while in this state. The croaking of the frog is principally uttered during the breeding-season, and when large numbers of these

Amphibians are collected in a pond together, the volume of sound produced is considerable, and can be heard from long distances, although it is nothing compared to that of the bull-frog and many tropical species. Frogs subsist entirely on slugs, snails, insects, etc., swallowing large beetles whole, and devouring several at a meal. The frog captures its prey by suddenly throwing forwards the tip of its tongue, which is invested with a viscid secretion, upon the insect or slug, and then as quickly withdrawing it to its normal inverted position. So rapid is the whole movement that it requires a sharp eye to detect it; the insect seeming to disappear as if by magic. "Frogs retire," writes Bell, "on the approach of winter to their hibernating retreats, where they pass the dreary season in a state of absolute torpidity. This is generally in the mud at the bottom of the water, where they are not only preserved, though at low degree, but also secured from external injury. Here they congregate in multitudes, embracing each other so closely as to appear almost as one continuous mass. On the return of spring they separate from each other, emerge from their places of retirement, and recommence their active life by exercising the important function of reproducing their species." During the breeding-season a warty protuberance is developed on the thumb of the male to assist in holding the female; and in some foreign species the whole fore-arm becomes enlarged at this time. The spawn is deposited at the bottom of the water, but soon rises to the surface in the well-known glairy masses; and in due season the tadpoles make their appearance. During the tadpole stage frogs are devoured in large numbers by newts and the smaller fishes; while in the adult condition numbers fall a prey to the weasel and pole-cat, the heron and other wading birds and the common snake, whose food is almost entirely composed of them. Although the common frog is to a large extent aquatic, it is much less so than the edible species, which inhabits indiscriminately running or still waters, the borders of rivers, rivulets, or streams, lakes or ponds, salt or fresh marshes, or even ditches and pools of water. Owing to the presence of the external sacs, the croaking of the male is louder than in the common frog. Both species, like all the more typical representatives of the genus, progress on land by means of leaps; while in water they swim with the hind-limbs alone.

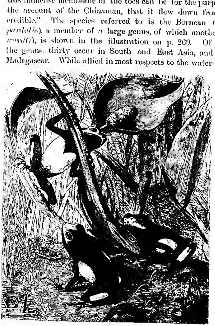
Bull-Frogs.

Compared to the bull-frog (*R. catesbyana*), of Eastern North America, represented in the figure on p. 259, the European frogs are mere dwarfs; but the largest species of all is Guppy's frog (*R. guppyi*), from the Solomon Islands, in which the length of the head and body is upwards of 9 inches. The bull-frog is one of those species in which the tips of the toes are pointed, and it is especially characterised by the web extending to the tip of the fourth toe of the hind-foot, the large size of the aperture of the ear, and the relative length of the hind-leg; the two latter characters distinguishing it from Montezuma's frog (*R. montezumae*), of Mexico. The body has no lateral glandular fold; and the vocal sacs of the males are internal. In colour the bull-frog is brown or olive above, with darker marblings; the under-parts being either uniformly coloured, or marbled with brown. In length it measures from 7 to 7½ inches, exclusive of the legs. More abundant in the southern than in the northern portion of its habitat, the bull-frog is generally met with in rivers and streams well shaded with trees or bushes, where it may be seen in numbers basking in the midday sun. Its croaking is said to be louder than that of any other species, and can be heard for a distance of several miles. In the Southern States of America, although most intense during the spring and summer, the croaking is continued throughout the year: but in the north it is confined to the spring and summer, being especially loud during the breeding-season. It is a remarkable fact that in Canada, at least, the bull-frog passes its first winter in the larval condition, and takes two years to attain its full growth.

Oxyglossus. It may be mentioned that the small Indian frogs forming the genus *Oxyglossus* differ from the members of the preceding genus by the absence of any notch in the tongue, and the want of vomerine teeth. They are specially interesting on account of being represented by fossil species in the Eocene rocks of Bombay. Fossil frogs belonging to the typical genus *Rana* occur in the lower Miocene rocks of Europe.


JAVAN FLYING FROG (⅔ nat. size).

Flying Frogs. "One of the most curious and interesting reptiles which I met with in Borneo," writes Mr. Wallace, "was a large tree-frog, which was brought me by one of the Chinese workmen. He assured me that he had seen it come down, in a slanting direction, from a high tree, as if it flew. On examining it, I found the toes very long, and fully webbed to their very extremity, so that when expanded they offered a surface much larger than that of the body. The fore-legs were also bordered by a membrane, and the body was capable of considerable inflation. The back and limbs were of a very deep shining green colour, the under surface and inner toes yellow, while the webs were black, rayed with yellow. The body was about 4 inches long, while the webs of each hind-foot, when fully expanded, covered a surface of 4 square inches, and the webs of all the feet together about 12 square inches. As the extremities of the toes have dilated discs for adhesion, showing the creature to be a tree-frog, it is difficult to imagine that this immense membrane of the toes can be for the purpose of swimming only, and the account of the Chinaman, that it flew down from the tree, becomes more credible." The species referred to is the Bornean flying frog (*Rhacophorus pardalis*), a member of a large genus, of which another representative (*R. reinwardti*), is shown in the illustration on p. 269. Of the forty-two species of the genus, thirty occur in South and East Asia, and the remaining twelve in Madagascar. While allied in most respects to the water-frogs, they all differ by the presence of a small additional bone between the terminal and penultimate joints of the toes, and likewise by the penultimate joints being distinctly marked externally as a kind of ridge; while they are further mostly characterised by the webbing of the toes of the fore-feet, although the degree to which this is carried is variable. The tips of the toes are always expanded into round discs, and very generally their terminal joints are forked. The males are provided with one or two internal vocal sacs. In habits these frogs are strictly arboreal; their bright green coloration harmonising with the leaves among which they dwell. The larvæ are remarkable for the possession of an adhesive disc behind the mouth on the under surface; while the muzzle is prolonged into a proboscis and the single breathing-pore is situated on the right side of the body, nearer to the tail than to the muzzle. Writing of the habits of one of the Cingalese members of the genus (formerly separated as *Polypedates*), in which the front toes are only half-webbed, Emerson Tennent observes that it 'possesses in a high degree, the faculty of changing its hues, one as green as a leaf to-day will be found grey and spotted like the back to-morrow. One of these beautiful little creatures, which had seated itself on the gilt pillar of a lamp on my dinner-table, became in a few minutes scarcely distinguishable in colour from the ormolu ornament to which it clung."



VARIABLE TREE-FROGS (nat. size).

THE SOLID-CHESTED TREE-FROGS

Family *DENDROBATIDÆ*

As we have already seen to be the case with the snakes, two totally distinct families of frogs have taken to an arboreal life and have thus become so like one another that we have to depend on anatomical differences for their distinction. In the present family, while the structure of the bones of the chest is of the same solid structure as obtains in the typical frogs, and the extremities of the transverse processes of the sacral vertebra are not expanded, an important difference presents itself in the absence of teeth in the upper jaw and on the palate. The toes of both feet are quite free from webs, and have their tips expanded into rounded discs. These frogs are represented by two genera, one of which (*Mantella*) is confined to Madagascar, and is distinguished by the tip of the tongue being notched; while in *Dendrobates* of Tropical America the tongue is entire. The American genus is represented by seven species, among which the variable tree-frog (*Dendrobates tinctorius*) is selected for illustration. This pretty little frog, which measures barely an inch and a half in length, is widely distributed in Tropical America, and is remarkable for its variability in colour; some examples being uniformly black, others grey above and black on the sides and beneath, and others grey with large black blotches. This, however, is by no means the limit of variation, since some examples are black above, with two or three longitudinal white or pink stripes, the under-parts being grey with black spots; while in other cases the ground-colour is black, with white spots and streaks above, and spots or marblings of the same beneath. From the small size of the discs on its feet, which do not admit of its clinging to upright stems, this frog seems to be less arboreal than some of its allies; and it is generally found among fallen leaves on the ground in forests. Like its kindred, it displays remarkable care and attention to its young. The secretion from its skin is employed by the Indians as an arrow-poison.

THE NARROW-MOUTHED FROGS

Family *ENGYSTOMATIDÆ*

An important family of the suborder is that of the narrow-mouthed frogs, represented by more than a score of genera, distributed over Africa, Madagascar, India and the adjacent countries, Southern China, Papua, and America. While agreeing with the members of the preceding family in the absence of teeth in the upper jaw, these frogs are distinguished by the broad expansion of the extremities of the transverse processes of the sacral vertebra. The vertebræ are similar in conformation to those of the typical frogs, and there is the same absence of ribs. There is, however, considerable variation in regard to the bones of the chest, several of the genera lacking the transverse bars commonly known as precoracoids; and the terminal joints of the toes may be either simple or T-shaped. Although there are no arboreal forms, the family comprises terrestrial, aquatic, and burrowing representatives; the last having either the front or hind-limbs specially strengthened and furnished with horny sheaths. In some of the genera, and especially the one of which a representative is here figured, the mouth is extremely narrow; and although it is convenient to take this character as the basis of the name of the family, it must not be considered that it is applicable to all its members. These narrow-mouthed forms feed exclusively or mainly on ants and termites and thus exhibit a modification of structure approximating to that characteristic of ant-eating mammals. More than half the members of the family are nocturnal, and may be recognised by the vertical pupil of the eye.

Short Headed Frogs The exceeding plumpness of the body serves not only to distinguish the short-headed frogs (*Breviceps*) from all their allies, but also makes them some of the most peculiar of their class. Indeed, when the body is puffed out to its fullest extent, they more resemble indiarubber balls than frogs. The genus belongs to a group in which the so-called precoracoid bones are present and the metacoracoids much dilated; and they are specially distinguished by the horizontal portion of the pupil and the absence of teeth on the palate. Three species are known, all of which are African, the one here figured (*B. mossambicus*) inhabiting the eastern districts. Generally having a perfectly smooth skin, this frog is of a brown or blackish hue on the upper-parts, with a dark oblique streak below the eye. The narrow mouth and long tongue of this curious frog indicate that its food consists of white ants.

EAST AFRICAN SHORT-HEADED FROGS (nat. size).

Darwin's Frog A frog (*Rhinoderma darwini*) belonging to the present family, and inhabiting Chili, alone represents a genus remarkable for the throat-sac of the males being enlarged and modified so as to form an extensive chamber on the under surface of the body in which the eggs and tadpoles undergo their development. This chamber is entered by two apertures situated on the floor of the mouth on each side of the tongue; and when the eggs, generally from eleven to fifteen in number, are laid by the female, they are taken and swallowed by her consort, who passes them into his pouch. When the tadpoles are sufficiently developed, they enter the world by escaping through the parental mouth. It appears that at no stage of their existence do the tadpoles possess external gills.

THE SHARP-NOSED FROG.

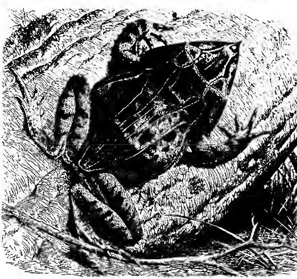
Family *CERATOBATRACHIDÆ.*

Omitting detailed mention of the small and unimportant family of the *Discophidæ*, characterised by the presence of teeth in the upper jaw, and the expansion of the extremities of the transverse processes of the sacral vertebra, our last representative of the first suborder is the sharp-nosed frog (*Ceratobatrachus guentheri*), of the Solomon Islands, which constitutes a family by itself. The essential characteristics of the family are the presence of teeth in both the upper and lower jaws (a feature found elsewhere only in two families of the next suborder), coupled with the absence of expansion of the extremities of the sacral vertebræ. This frog has a very large triangular head, ornamented with prominent ridges, and terminating in front in a pointed flap of skin; similar flaps occupying the eyelids, and the mouth having an enormous capacity. In the eye the pupil is horizontal; and teeth are present on the vomers. The hind-limbs are rather short; and all the toes have simple terminations, and are devoid of webs. In colour this curious frog is very variable. Although very little is known as to its habits, it appears to be abundant in the Solomon Islands; and it is remarkable for laying very large eggs, from which the young emerge nearly fully-developed.

THE SOUTHERN FROGS.

Family *LEPTODACTYLIDÆ.*

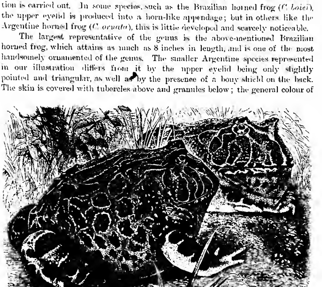
In the greater part of South America and the whole of Australia the typical frogs are replaced by a family which, for want of a better name, we may call the southern frogs. These, together with seven other families, differ essentially from the forms hitherto considered, in regard to the conformation of the bones of the chest, and thus collectively constitute a second suborder, known as the Arcifera. It will be remembered that in the preceding suborder the two metacoracoid bones are connected together by a single cartilage joining their free edges; in the present group each metacoracoid terminates in a large cartilage, in such a manner that one cartilage overlaps its fellow of the opposite side. The southern frogs resemble the typical frogs in having the upper jaw alone toothed, and in the transverse processes of the sacral vertebra being cylindrical or but slightly expanded, while they also agree in the characters of the vertebræ and the absence of ribs. It is thus evident that the two groups form parallel or representative series; but it must always be remembered that it is only an assumption that the conformation of the bones of the chest is the character of primary import, and that it is quite possible that there may have been parallelism in this case also, in which event the present family would have to be placed next the true frogs. The present family is confined to the countries mentioned above, and is represented by twenty-five genera and some one hundred and eighty species. While most of the American forms have the pupil of the eye vertical, this condition occurs but rarely in those from Australia.



SOLOMON ISLAND SHARP-NOSED FROG (nat. size).

Horned Frogs. Among the best known representatives of the family are the horned frogs, or horned toads (*Ceratophrys*), remarkable alike for their large size and brilliant coloration, as well as for the enormous dimensions of their mouths and their fierce and carnivorous habits. Represented by about half a score of species from Tropical and South America, they belong to a group characterised by the more or less marked union of the outer metatarsals, the absence of a bony style to the breast-bone, and the webbing of the hind-toes; while, as a genus, they are distinguished by the horizontal position of the pupil and the notching of the tongue. The webbing of the toes varies in extent in the different species, but there is never any expansion of these extremities. The outer metatarsals are completely united, and the skull is remarkable for the extent to which ossification is carried out. In some species, such as the Brazilian horned frog (*C. boiei*), the upper eyelid is produced into a horn-like appendage; but in others like the Argentine horned frog (*C. ornata*), this is little developed and scarcely noticeable.

The largest representative of the genus is the above-mentioned Brazilian horned frog, which attains as much as 8 inches in length, and is one of the most handsomely ornamented of the genus. The smaller Argentine species represented in our illustration differs from it by the upper eyelid being only slightly pointed and triangular, as well as by the presence of a bony shield on the back. The skin is covered with tubercles above and granules below; the general colour of the upper-parts being yellowish or greenish, with large olive spots surrounded by light-coloured or golden margins, while there are sometimes wine-red lines between the spots. These frogs, or escuerzos, as they are locally called, are abundant in many parts of Argentina, and in damp weather may be met with crawling about among the grass in numbers, after the manner of toads. They are exceedingly bold and ferocious, flying fiercely at anyone who attacks them, and maintaining their hold with the tenacity of a bull-dog, at the same time uttering a kind of barking cry. On other occasions they give vent to a peculiarly deep bell-like note. When in repose, escuerzos are in the habit of burying themselves in the soil with only the top of the back exposed, in which state they are almost invisible. In this position they lie in wait for their prey, which includes other frogs, birds, and small mammals; and at times they capture and attempt to swallow objects too large for their capacity.



ARGENTINE HORNED FROGS, OR ESCUERZOS (nat. size).

Leaf-Frogs. Another American genus, containing a very large number of species, is that of the leaf-frogs (*Hylodes*), which deserves mention on account of the peculiar reproduction of one of its representatives, the so-called Antillian frog (*H. martinicensis*). These frogs differ from the group to which the last genus belongs by the absence of a bony style to the breast-bone, and the unwebbed hind-toes; while they are further characterised by the expansion of the tips of the toes into smooth discs, the horizontal pupil of the eye, and the presence of teeth on the vomer. The Antillian frog, or, as it is locally termed, coqui, is an inhabitant of several of the West Indian Islands, and may be recognised by its warty under surface; the general colour of the upper-parts being grey or brownish, with indistinct darker marking on the head and back, and crossbars on the hind-legs; while there is a large dark mark on the temporal region, and another near the muzzle. The remarkable fact connected with the reproduction of this species is that such transformations as are undergone by the larvæ take place within the large eggs; the creatures emerging from which undergo no further alteration, with the exception of the absorption of the remnant of the tail. In this respect the coqui resembles the sharp-nosed frog of the Solomon Islands.

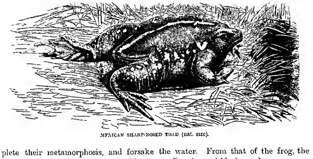
Piping Frogs. As the typical representatives of the family, brief mention must be made of the piping frogs (*Leptodactylus*) of Central and South America, which differ from the preceding genera in having a dagger-like bony style to the breast-bone, and having the pupil of the eye horizontal, and the teeth on the vomers placed behind the apertures of the inner nostrils. Externally, these frogs closely resemble the ordinary European water-frogs, with the exception that the hind-toes are not webbed. In the males the humerus is expanded into a large flange-like plate, and in the breeding-season the whole fore-limb is much swollen for the purpose of firmly holding the female. These frogs derive their names from their loud pipe-like croaking, which varies in tone and intensity according to the species. Some are noteworthy from their habit of digging a hole in the ground near water, and lining it with a layer of scum, upon which the eggs are deposited, and left to hatch. The nests seem, however, always to be so placed that at a certain season they will be flooded by the rise of the neighbouring water. When first hatched, the tadpole is not unlike that of the frog, although with a relatively smaller tail; and when the nest becomes flooded the mode of life of its occupants is similar to that of the ordinary frog-larvæ.

THE TOADS.

Family *BUFONIDÆ*.

Passing over the unimportant family of the *Dendrophryniscidæ*, including only two small South American genera, our next representatives of the suborder are the true toads, which constitute a family distinguished by the absence of teeth in both jaws, and the expansion of the extremities of the transverse processes of the sacral vertebra. The vertebræ resemble those of the typical frogs, and there is the same absence of ribs as in the latter. The terminal joints of the toes are either blunt, or T-shaped; and in only two out of the eight genera is the pupil of the eye vertical. Two of the genera approximate in character to the preceding family. The toads have an almost cosmopolitan distribution, and while the more typical forms are characterised by their terrestrial habits, rough skin, and creeping gait, so unlike that of the frogs, others are burrowing, and others, again (*Nectes*), thoroughly aquatic. Moreover, the disc-fooled toads (*Nectophryne*) of Western Africa and the Oriental region, in which the toes terminate in disc-like pads, appear to be arboreal; while the one Mexican representative of another genus (*Rhinophrynus*) is distinguished by its ant-eating habits.

True Toads. The common toad (*Bufo vulgaris*) is the typical representative of a large genus, with some eighty-five species, ranging over the whole world, with the exception of Madagascar, Australia, New Guinea, and the islands of the Pacific. As a genus, the true toads are distinguished by the entire tongue, the horizontal pupil of the eye, the freedom of the toes of the fore-foot, and the partial webbing of those of the hind-limbs, as well as by the breast-bone being either cartilaginous or with only a partially ossified style. The degree of webbing of the hind-toes varies; and while the tips of the toes are generally simple, they are sometimes expanded into small discs. The head may or may not have bony ridges. The common toad belongs to a group characterised by the absence of these ridges, and by the hind-toes being at least half-webbed; while it is specially distinguished by the absence of a fold on the ankle, and by the tubercles beneath the joints of the hind-toes being mostly double. On the upper-parts are more or less prominent warts, which, although frequently spiny, are not distinctly porous; and the glands behind the eyes are remarkably prominent, and of an elongated elliptical form. In colour, the upper-parts are brownish, with darker spots or marblings; while the lower surface is whitish, more or less thickly spotted with black. A black line runs on the outer side of the gland behind the eye; this line, in specimens from China and Japan, extending along the upper side of the flanks. The distributional area of the species includes Europe, Asia (exclusive of India and adjacent regions), and North-Western Africa. Few animals have suffered more from popular superstition than the common toad, which, although practically harmless, has been almost universally shunned and detested. It is, however, true that the secretion from its skin is acrid and irritating, as may be seen by the foaming lips of dogs which attempt to meddle with these amphibians. Sluggish and terrestrial in its habits, the toad needs not the long and fully-webbed hind-limbs of its active cousin, the frog; its usual pace being a kind of crawl, although, when disturbed, it can execute an imperfect leap. When alarmed, or threatened with danger, a toad immediately stops and puffs out its body to its utmost capacity, at the same time causing the acrid secretion to exude from the pores of its skin, and likewise discharging a pure limpid fluid from a special reservoir. Of its general habits, Bell writes that the toad "becomes torpid during the winter, and chooses for its retreat some retired and sheltered hole, a hollow tree, or a space amongst large stones, or some such place, and there remains until the return of spring calls it again into a state of life and activity. Its food consists of insects and worms of almost every kind. It refuses food which is not living, and, indeed, will only take it at the moment when it is in motion. When about to feed, the toad remains motionless, with its eyes turned directly upon the object, and the head a little inclined towards it, and in this attitude it remains until the insect moves, when, by a stroke like lightning, the tongue is thrown forward upon the victim, which is instantly drawn into the mouth. . . When the prey is taken, it is slightly pressed by the margins of the jaws; but as this seldom kills it, unless it be a soft tender larva, it is generally swallowed alive. Toads will also take earth-worms of considerable size; and it is a curious sight to watch the manner in which the powerful and writhing worm is secured. If the toad happen to take it by the middle, the extremities of the worm are twined with great force and activity around the muzzle of its captor in every direction, in its attempts to escape; but the toad pushes one portion after another into its mouth, by means of the fore-feet, until it all disappears, when it is swallowed whole." The eggs of the toad differ from those of the frog in that, instead of forming an irregular mass with their enclosing jelly, they are arranged in a regular, double, and alternating series in the form of a string, which may be a yard or more in length. These strings are generally deposited in the water about a fortnight later than the spawn of the frog; and it is not till autumn that the young toads complete their metamorphosis, and forsake the water. From that of the frog, the tadpole of the toad is distinguished by its smaller size and blacker colour.



MEXICAN SHARP-NOSED TOAD (nat. size).

Green Toad. The green toad (*Bufo viridis*) of Europe, Asia, and Northern Africa, is a far handsomer species, distinguished by the presence of a fold on the ankle, and likewise by the simple structure of the tubercles on the lower surface of the toes of the hind-foot. There is likewise a vocal sac beneath the throat of the male, which is wanting in the common toad. The upper-parts carry a number of irregular, flattened, and porous warts; and the glands behind the eyes, although sometimes enormously developed, are generally of moderate size and more or less kidney-shaped. The colour is olive or greenish above, generally spotted or marbled with a darker shade, although occasionally nearly uniform; while the under-parts are either uniformly whitish, or whitish with dark spots.

Natterjack Toad. A third European species, which, unlike the last, is locally represented in England, is the natterjack toad (*B. calamita*), easily recognised by the yellow or whitish line running down the middle of the back. From both the preceding it is distinguished by the much smaller extent of the webbing of the hind-toes; while there is a fold on the ankle, and the tubercles on the joints of the lower surface of the hind-toes are to a large extent double. The hind-limb is unusually short, the flattened warts on the back are distinctly porous; the glands behind the eyes are small, depressed, and either oval or triangular; and there is an additional gland on the leg. The general colour of the upper-parts is light olive, with darker marblings or spots, the above-mentioned light line being generally present; while the light under-parts are more or less spotted with black. In its movements the natterjack is less sluggish than the common toad, its pace being often quickened to a kind of run, during which the body is raised considerably above the ground. It is likewise less intolerant of drought, being frequently found in hot, sunny situations, and only resorting to the neighbourhood of water during the breeding-season.

Sharp Nosed Toad. The Mexican sharp-nosed toad (*Rhinophrynus dorsalis*), already referred to as subsisting on white ants, is the only other member of the family that we have space to mention, and is generically distinguished by the long and narrow tongue being free in front, by the vertical pupil of the eye, and by the rudimentary breast-bone. The front-toes are free, and those of the hind-limb webbed, with simple tips; while the general form of the body is extremely stout; the head small, with a long, truncated muzzle and narrow mouth; the eyes being small, and the limbs remarkably short. In colour this toad is olive-brown or bluish grey above, frequently with yellowish spots on the flanks and middle of the back, those on the back sometimes uniting to form a line.

THE OVERLAPPING-CHESTED TREE-FROGS.

Family *HYLIDÆ.*

The numerous, mostly arboreal, frogs thus designated form a family comprising some ten genera, very abundant in Australia and America, and more sparingly represented in Europe, Asia north of the Himalaya (one species ranging into North-Eastern India and Burma), and Northern Africa. While resembling the toads in the expansion of the processes of the sacral vertebra, they differ by the presence of teeth in the upper jaw, and they are peculiar in the claw-like form of the terminal joints of the toes. The vertebræ are cupped in front, and spherical behind, and there are no ribs.

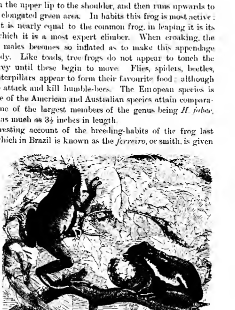
GRASSHOPPER-FROGS (nat. size).

Grasshopper-Frog. The grasshopper-frog (*Acris gryllus*) of North America is the sole representative of a genus characterised by the horizontal pupil of the eye, the webbing of the hind-toes, of which the tips are but little expanded, and the slight expansion of the processes of the sacral vertebra. In form this little frog is slender, with a narrow head and rather sharp muzzle, while the skin of the upper-parts is either smooth or slightly tuberculated, and that of the under-parts granulated. The mottled and striped coloration is very variable, the ground-tint ranging from reddish brown to green; but there is generally a large, triangular, dark brown spot between the eyes, and sometimes a light stripe down the back. Locally very abundant in Eastern and Central North America, the grasshopper-frog derives its name from its piercing, strident cry, which resembles the noise of its insect namesake. It frequents stagnant waters, and is fond of resting on the leaves of aquatic plants. Unlike most of its allies, it lurks among plants, and seldom, if ever, ascends bushes or trees.

Typical Tree Frogs. Closely allied to the last are the numerous species of typical tree-frogs (*Hyla*), which are by far the most beautiful representatives of the entire order, and are best known by the common European species. In this genus the pupil of the eye is horizontal, the toes of both limbs dilated into discs, and those of the hind-foot more or less extensively webbed, the tongue either adherent or more or less free behind, and the expansion of the transverse processes of the sacral vertebra more or less strongly marked. As in the last genus, there are teeth on the vomers. Represented by about one hundred and fifty species, this genus has a distribution coextensive with that of the family; the sole Indian member of the latter being included. The under surface of their bodies is very different to that of the terrestrial species; for the skin, instead of being smooth, is covered with granular glands, pierced by numerous pores, through which the dew or rain, spread on the surface of the leaves, is rapidly absorbed into the system, and reserved to supply the moisture necessary for cutaneous respiration. Except during the breeding-season, when the greater number of them seek the water, or when they retire before the cold of winter or drought of summer under mud, beneath stones, the bark of trees, or in other safe spots, these frogs spend their lives among the leaves of trees, where they find alike their dwelling-places and their hunting-grounds. As in the case of the flying frogs, their colour harmonises exactly with their natural surroundings, and changes even more rapidly than that of the chamæleons. So exactly indeed do they resemble the foliage among which they hide, that it is often difficult to tell frogs from leaves; and it has been noticed that where there is the greatest variety and brilliancy of colour among the forest trees, the tree-frogs attain their most brilliant and varied tints.

The European tree-frog (*H. arborea*), which is one of three species inhabiting the Old World proper, has a wide geographical distribution, inhabiting the greater part of Europe, Asia north of the Himalaya as far east as Japan, and North Africa. With the exception of the higher mountain ranges and the extreme north, as well as Norway and Britain, it is spread over the whole of Europe, although varying locally to a considerable degree in coloration and habits. The males are furnished with a large external vocal sac on the throat, and the skin is smooth above and granulated beneath. The general coloration may be described as greenish above, and uniform whitish beneath, but there are many variations in regard to the markings on the upper-parts; the typical form having a greyish or black light-edged streak extending from the nostril through the eye and ear along each side of the body, and sending a branch upwards and forwards on the loin, while a whitish line descends from the upper lip to the shoulder, and then runs upwards to the eye, thus enclosing an elongated green area. In habits this frog is most active; and while in swimming it is nearly equal to the common frog, in leaping it is its superior, in addition to which it is a most expert climber. When croaking, the sac on the throat of the males becomes so inflated as to make this appendage nearly as large as the body. Like toads, tree frogs do not appear to touch the insects on which they prey until these begin to move. Flies, spiders, beetles, butterflies, and smooth caterpillars appear to form their favourite food; although they have been known to attack and kill humble-bees. The European species is of very small size, but some of the American and Australian species attain comparatively large dimensions, one of the largest members of the genus being *H. faber*, of Brazil, which measures as much as 3½ inches in length.

Nesting-Habits. An interesting account of the breeding-habits of the frog last mentioned, which in Brazil is known as the *ferreiro*, or smith, is given by Dr. Goeldi, whose observations were made in the Organ Mountains, adjoining the bay of Rio de Janeiro. This frog makes regular pools of a circular form in the shallow borders of ponds and swamps, such pools being surrounded by a narrow mud-wall. In 1894 one pond contained nine of these pools, which serve as nests for the tadpoles. "On the night of the 18th of February," writes the describer, "between nine and eleven o'clock, we approached the pond, occupied, as we could hear from a distance, by at least a dozen of the large tree-frogs. The moon was shining brightly, and much favoured our undertaking, but even under these circumstances we had to accustom our sight to discern the details in the marginal vegetation, and the portion somewhat hidden in the shadow. By and by we discovered the ferreiros, some at work, others drumming together on the walls of some pool, or in the middle of the pond, sitting upon some floating object, such as water-plants. The vocalists of which we could distinguish the moderately inflated gular sacs, were all males." After stating that he was posted on a side of the pond where five nests were already situated, Dr. Goeldi observes that he and his companion were fortunate enough to see the rising of a new nest. In a certain spot he writes that "we


EUROPEAN TREE-FROGS (nat. size).

first saw some slight movement in the water, produced by something stirring below the surface. We then soon saw a mass of mud rising to the surface, carried by a tree-frog, of which no more than the two hands emerged. Diving again, after a moment's time, the frog brought up a second mass of mud, near the first. This was repeated many times, the result being the gradual erection of a circular wall. From time to time the head and front part of the body of the builder appeared suddenly with a load of mud at some point; but what astonished us in the highest degree was the manner in which the frog used its hands for smoothing the mud-wall, as would a mason with his trowel. And by examining the hands of this hyla, it will readily be understood how they are most serviceable trowels, their terminal joints bearing large expansions. This careful process of smoothing could be better observed as the wall gradually heightened, until it reached about four inches, when the frog was compelled to come out of the water. The parapet of the wall receives the most careful smoothening, the outside being neglected, and the levelling of the bottom attained by the action of the lower surface of the creature's body, aided by the hands. The aspect of the pool may be compared to the crater of a volcano, or a vessel of a foot in diameter filled with water. Although the female undertakes the entire task of building, she is incommoded the whole time by the male sitting on her back. Should he be frightened from his post, he will soon emerge from the water at a distance of a few feet, when, if signs of danger be wanting, he will climb the walls of the nest and regain his original seat."

Another Brazilian tree-frog of the same genus (*H. goeldii*) breeds in the water contained in the central cup of certain trees belonging to the *Bromeliaceæ*. Dr. Goeldi states that the first specimen found was a female, carrying on her back a large globular mass of whitish eggs. When put in a vivarium, "for a few days the egg mass remained attached to the mother's back. But suddenly it fell away, and simultaneously I saw in the glass some small, nearly black coloured frogs all provided with the anterior and posterior legs, together with a larval tail of medium or rather small size."

Yet another tree-frog from Brazil (*H. nebulosa*) has acquired the remarkable habit of depositing its eggs in the sheaths of old and decaying leaves of bananas. The writer from whom we have been quoting states that this frog "glues its lumps of eggs on the edges and on the inside of banana leaves, where, even during the hot hours of the day, sufficient coolness and moisture are preserved. These lumps are enclosed in a frothy, whitish substance, comparable to the scum formed by certain *Cicadidæ*. Sometimes the tailed larvæ are seen struggling in this frothy mass. If put into fresh water, all will die in a few hours."

Pouched Tree-Frogs.

On account of the peculiarity of their reproduction, mention must be made of the curious pouched tree-frogs (*Nototrema*), distinguished from the typical genus by the presence of a backwardly-opening pouch at the hinder-end of the back in the females. These frogs are represented by some half-dozen species, mainly confined to Central and Western Tropical America, although one of their number is found on the eastern side of that continent at Pernambuco. The pouch of the female is extended beneath the skin of the back and sides to form a very large chamber, in which the eggs and tadpoles undergo the whole of their transformations. The eggs, generally fifteen or sixteen in number, appear to be placed in the pouch by the male, who employs his hind-feet for the purpose; and they are remarkable for the large relative size of the yolk. The tadpoles, when first hatched, are peculiar in having a bell-shaped structure for the protection of their two pairs of external gills.

THE TOAD-FROGS.

Family *PELOBATIDÆ.*

The fifth family of the order belonging to the section with overlapping cartilages to the metacoracoids comprises eight genera, which may be collectively termed toad-frogs, since they come neither under the designation of toads or frogs. Agreeing with the tree-frogs in the presence of teeth in the upper jaw, they may be distinguished by the much greater expansion of the processes of the sacral vertebra, ribs being absent, and the terminal joints of the toes simple. In all the forms the pupil of the eye is vertical; and whereas the majority of the genera agree with the preceding groups in having the articular cup at the front and the ball behind, in a few this arrangement is reversed. The family is distributed over Europe, the Oriental region, North America, and New Guinea; the various genera having a more or less restricted geographical range.

Brown Toad Frog. The brown toad-frog (*Pelobates fuscus*) is the typical representative of a genus containing two European species, neither of which are found in Britain. They are characterised by the rod at the end of the backbone being welded to the sacral vertebra, and by the extensive webbing of the hind-toes; the presence of a bony style to the breast-bone, coupled with the want of an externally visible ear-membrane, serving to distinguish them from an allied North American genus (*Scaphiopus*). The brown toad-frog is a rather large species, usually measuring from 2½ to 3 inches in length, and having a smooth brown skin, marbled on the upper parts with darker markings; a spur which is present on the metatarsus being yellowish brown. The males have no vocal sac, but are furnished with a large elliptical gland on the upper surface of the fore-limb. This species is decidedly local, and in some districts is replaced by the allied *P. cultripes*, easily distinguished by the black spur on the metatarsus. Spending only a few days during the breeding-season in the water, it is essentially a land animal, generally frequenting spots with a sandy soil. Here, with the aid of its metatarsal spur, it rapidly excavates hollows in the ground, throwing out the earth backwards, and soon partially concealing itself. An aperture is, however, always left to the excavation, and should the rays of the morning sun reach its occupant, the burrow is quickly deepened. In its movements the toad-frog is more active than the toads, approaching in this respect the frogs, as it takes considerable leaps, swims strongly, and burrows with rapidity. The breeding-season takes place in April, during which time the males utter a loud croaking, accompanied in a lower tone by the females. The eggs are laid in strings of about a couple of feet in length; and are taken from time to time by the male and carefully deposited round reeds, grass, or other plants growing near the edge of the water. In from five to six days the small black tadpoles are hatched out; and in the course of four months these have completed their development and leave the water. When an adult toad-frog is suddenly seized or pinched, it utters a cry like the mewing of a kitten, at the same time emitting a pungent vapour with a strong odour of garlic, both these being apparently intended as a means of defence.

Other Genera. Of the remaining genera, *Pelodytes*, as represented by the punctured toad-frog (*P. punctatus*) of Western Europe, and the Papuan *Batrachopsis*, differ from the preceding in that the sacral vertebra has two condyles for articulation with the rod forming the termination of the backbone, the hind-toes being slightly webbed. In the Oriental genus *Leptobrachium*, there is but a single condyle for the articulation of the rod-like bone.

Allied Extinct Frogs. In the Miocene rocks of Europe there occur remains of numerous frogs which are assigned to an extinct genus, *Palæobatrachus*, regarded as representing a family (*Palæobatrachidæ*) connecting the present one with the under-mentioned *Xenopodidæ*. In these extinct forms the upper jaw is toothed, the transverse processes of the sacral vertebra have expanded extremities; the sacral vertebra articulates with the terminal rod of the backbone by means of two condyles; the vertebræ have their articular cup in front; and there are no ribs.

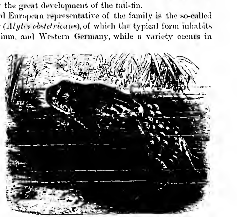
The Disc-Tongued Frogs.

Family *DISCOGLOSSIDÆ*.

The disc-tongued frogs, as the members of this group may be called, form a small family represented by four genera and seven species, inhabiting the northern half of the Old World and New Zealand. As a family, these frogs are characterised by the presence of teeth in the upper jaw, the expansion of the processes of the sacral vertebra, the presence of short rudimentary ribs, and the circumstance that in the bodies of the vertebræ the articular cup is placed at the hinder-end, and the ball in front. In both the latter respects these frogs resemble the salamanders and newts, and they may accordingly be regarded as some of the least specialised representatives of the order. Their remains occur abundantly in the middle Tertiary rocks of Europe. The family derives its name from the disc-like form of the tongue, which may be either free or adherent. From all the forms hitherto described, the tadpoles, after shedding the external gills, differ in having the breathing-pore situated in the middle of the under surface of the body, instead of on the left side.

Fire Bellied Frog. From the painted frog (*Discoglossus pictus*) of Southern Europe and North-Western Africa, which alone represents the typical genus of the family, the fire-bellied frog (*Bombinator igneus*), represented in the figure on p. 257, is distinguished by the absence of an external tympanic membrane to the ear; while it is further characterised by the adherent tongue, the triangular form of the pupil of the eye, and the great expansion of the extremities of the transverse processes of the sacral vertebra. This frog, which inhabits Europe and Asia, although unknown in the British Islands, has the skin very warty on the upper-parts, while beneath it is nearly smooth. In colour it is olive above, with or without black marblings; while beneath it is orange or yellow, marbled with black. The males are devoid of a vocal sac, but during the breeding-season they develop black rugosities on the inner side of the fore-arm, as well as on the inner tubercle of the metacarpus, and on the two innermost front-toes. There are two varieties of this frog (reckoned by some as distinct species), of which the one with orange-coloured under-parts is to be found in streams or marshes in the lowlands, while the yellow-bellied form lives at considerable elevations in the mountains. They are essentially aquatic frogs, only leaving the water for a short time in the spring, when they may be seen hopping on the land on their long hind-legs. In the water they generally take up their position at some distance from the bank, sitting with their heads slightly raised above the surface, and disappearing with lightning-like speed at the slightest noise, to seek safety in the mud at the bottom. The tadpoles grow to an unusually large size, and are especially characterised by the great development of the tail-fin.

Midwife Frogs. The third European representative of the family is the so-called midwife-frog (*Alytes obstetricans*), of which the typical form inhabits France, Switzerland, Belgium, and Western Germany, while a variety occurs in Spain and Portugal, Spain being also the home of the second member of the genus (*A. cisternasii*). From the fire-bellied frog these two species are distinguished by the distinct external tympanic membrane to the ear, the elliptical and vertical pupil of the eye, and the moderate expansion of the transverse processes of the sacral vertebra. The common species has the skin of the upper-parts warty, while that of the under surface is granular; the glands near the head are small or indistinct, but there are large ones on the limbs; and the males have no vocal sac. The colour of the upper-parts is olive-grey, with darker dots and irregular spots. Essentially an aquatic species, this frog derives its name from the circumstance that the male takes charge of the eggs during their development. The breeding-season lasts for upwards of six months, namely, from March to August, although the eggs are laid only from March till June. These are deposited by the female in the form of long chains, which may be upwards of a yard and a half in length. These chains are taken by the male, and wound round his legs and thighs: and when thus loaded he retires to some burrow or convenient hollow near the bank, where, at least during the daytime, he remains in concealment until the tadpoles are ready for hatching. He then enters the water, and the tadpoles soon come forth, and swim away to take care of them-



MALE OF MIDWIFE-FROG WITH CHAINS OF EGGS (NAT. SIZE) selves; the hatching of the tadpoles taking place from June till September. After the cares of the nursing period are over, the male loses his voice, which is not resumed till the following February, when it is continued till August. The males are more numerous than the females, and during the breeding-season their loud croaking is almost continuous. From September till the beginning of March the habits of this sex are similar to those of other frogs. The lower Miocene strata of the Continent have yielded remains of an extinct frog belonging to the same genus; while in the rocks of the upper part of the same division of the Tertiary period there occurs a gigantic frog belonging to the same family, which has been referred to an extinct genus, under the name of *Latonia*.

Other Families. The other two families—*Amphignathodontidæ* and *Hemiphractidæ*—belonging to the present suborder are not of much importance, and are represented only by a small number of genera and species from Central and South America. They are, however, of some interest, from the circumstance that both the upper and lower jaws are furnished with teeth, in which respect they agree with the sharp-nosed frog among the members of the first suborder.

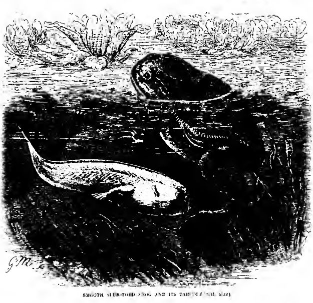
THE TONGUELESS FROGS.

Families XENOPODIDÆ and PIPIDÆ.

The members of the order hitherto considered are furnished with a well-developed tongue, but in the order Aglossa, this organ is totally wanting. The vertebræ resemble those of the disc-tongued frogs in having their articular cups at the hinder-ends, but ribs are wanting. The metacoracoids correspond in structure to those of the suborder Arcifera, although the cartilages at their edges do not overlap. The tadpoles of these remarkable frogs exhibit the peculiarity of having a pair of breathing-pores, after the loss of the external gills, situated symmetrically on each side of the body. Each family is represented by a single genus, respectively confined to Tropical Africa and Tropical South America.

Spur-Toed Frog. The spur-toed frogs (*Xenopus*), of which there are three species from Tropical Africa, are characterised as a family by the presence of teeth in the upper jaw; while they are further distinguished by the circular pupil of the eye, the absence of an external tympanic membrane to the ear, the free front-toes, and the webbed hind-foot, in which each of the three inner-toes is furnished with a sharp, spur-like nail. The smooth spur-toed frog (*X. lævis*), which is the species here represented, has a wide geographical distribution, ranging from Abyssinia to the Cape; and is characterised by its smooth skin, marked round the body with more or less distinctly defined tube-like lines. In colour it is dark brown above, and whitish beneath; some individuals being uniform, while others are spotted with brown on the under surface. The spur-toed frogs are exclusively aquatic, pursuing even their prey beneath the surface of the water, and capturing it with their fore-feet. The pairing-season takes place in August, and the large eggs are laid singly. The tadpoles, which at birth have already lost their external gills, on the third day after leaving the eggs develop a pair of barbels hanging down from the corners of the mouth.

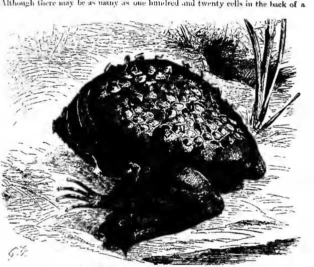
Surinam Water Toad. The second family, distinguished by the absence of teeth in both jaws, is represented solely by the Surinam water-toad (*Pipa americana*), which has long enjoyed a worldwide reputation, on account of the very singular manner in which the eggs are lodged during the period of their development. Agreeing with the spur-toed frogs in its circular pupil, smooth palate, and absence of a tympanic membrane to the ear, the Surinam toad has the extremities of the free front-toes dilated into radiating appendages, while the



SMOOTH SPUR-TOED FROG AND ITS TADPOLE (NAT. SIZE).

fully-webbed hind-toes are devoid of nails. In form the head is triangular and much depressed, with the eye minute, one or two short tentacles on the lip in front of the eye, a large flap at each corner of the mouth, and sometimes a third at the tip of the muzzle. The skin, which is covered with small tubercles, is olive-brown or blackish on the upper-parts, while beneath it is lighter, being sometimes ornamented with white spots, and at others with a black stripe down the middle line.

The Surinam toad is an inhabitant of the damp forests of the Guianas and Brazil, and the females deposit their eggs after the usual manner in the water. At this period the skin of the back of the female becomes extremely soft and much thickened and the eggs, as soon as laid, are taken by the males and embedded one by one in this softened skin, which soon closes over, so as to enclose each in a separate cell. In these cells the eggs undergo the full course of development, the juvenile toads issuing forth from their confinement in a perfect condition, although their dimensions are, of course, small, and no gills being developed at any stage. Although there may be as many as one hundred and twenty cells in the back of a

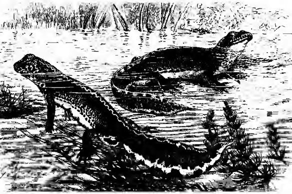


FEMALE SURINAM WATER-TOAD, SHOWING YOUNG IN THEIR CELLS (⅔ nat. size).

single individual, the more usual number is from sixty to seventy. The period from the deposition of the eggs to the appearance of the young toads is eighty-two days, and the young, when first bursting through the covering of their cells, generally protrude the head or one limb. Soon after the birth of her offspring the female changes the superficial layer of her skin by rubbing it off against stones or plants; the place occupied by each cell being then indicated by a small pit. Except during the breeding-season, the pipa appears to be completely aquatic.

CHAPTER II.

NEWTS, SALAMANDERS, AND CŒCILIANS,— Orders CAUDATA AND APODA.



ALPINE NEWTS.

THE newts and salamanders are readily distinguished from the frogs and toads by the retention of the tail throughout life. Hence they are collectively designated the Tailed Amphibians. Although they have generally two pairs of limbs, in a few instances the hind pair is wanting; and in all cases the bones of the limbs are of a normal type, the radius and ulna in the front pair, and the tibia and fibula in the hind ones remaining distinct from one another. In the skull the frontal bones are not united with the parietals, and the palatine bones are distinct from the jaw-bones or maxillae. Generally more or less lizard-like in form, the Tailed Amphibians undergo a less marked metamorphosis than the tailless group, some even retaining gills throughout life. As regards their geographical distribution, the salamanders and newts, of which there are rather more than one hundred and twenty existing species, are mainly characteristic of the Northern Hemisphere, being represented only by a few scattered forms in the Southern Hemisphere and quite unknown in Africa south of the Sahara and in Australasia. The northern part of the Old World is the home of the true newts, of which four species extend into Northern Africa; and it likewise contains one of the fish-like salamanders and the olm. True newts are very abundant in the western portion of this region, but as we proceed eastwards they become less numerous, and we notice an approximation to American types of the order, although only two genera are common to the Old and New Worlds. North America is especially rich in Tailed Batrachians, containing more than half the representatives of the entire suborder, and having the two-legged salamanders (*Sirenidæ*) peculiar to it. Axolotls are here especially abundant, and there are also peculiar genera belonging to the families of the fish-like and gilled salamanders. The Oriental region possesses only two species, namely, a peculiar genus (*Tylotriton*) of newts in Yunan and the Eastern Himalaya, and an axolotl in Siam. Tropical America, on the other hand, has ten species; among which may be specially noticed the newts of the genus *Spelerpes*, which are also represented by one species from Central America and the West Indies, and two others from the mountains of Colombia, Ecuador, and Northern Peru. Geologically, the group is by no means an old one, its earliest known representative (*Hylæobatrachus*) occurring in the Wealden strata of Belgium; and these animals do not appear to have become abundant until the Tertiary epoch.

Nearly all newts and salamanders appear to be inhabitants of water during at least some period of their existence: some frequenting muddy swamps, and others deep lakes or subterranean waters, while a few are found in mountain-tarns at elevations of several thousand feet above the sea. Without exception nocturnal in their habits, spending the day in slumber either concealed in hiding-places on land, or at the bottom of the water in their aquatic haunts, and venturing abroad only at evening or after heavy rain, they are all difficult of observation, and consequently much still remains to be learnt with regard to their mode of life. The terrestrial species generally frequent soft, shady, damp spots, but occasionally narrow valleys or forests where they conceal themselves under stones or fallen trunks of trees, or in holes in the earth. During their permanent or temporary sojourn in the water, the adults of those species unprovided with external gills are obliged to come periodically to the surface in order to breathe; and while in that element all are less completely nocturnal than when on land. Such species as are inhabitants of cold regions undergo a period of torpidity during the winter months; while in tropical regions others become quiescent when their haunts are dried up. They exhibit a wonderful tenacity of life; and when dried up in mud, or frozen in ice, will awaken at the first shower of rain, or when their icy bonds are dissolved by the sun's rays. They have also the capacity of reproducing lost limbs, apparently any number of times. Although on land the majority of species are slow and sluggish in their movements, some salamanders from the south and west of Europe, belonging to the genera *Salamandrina* and *Chioglossa*, run with the celerity of lizards; while others, again, climb sloping or perpendicular faces of rock, like geckos. In the water all swim quickly, mainly by means of serpentine movements of the tail; although the water-newts are perhaps the most expert swimmers. All are carnivorous in their diet, feeding chiefly upon molluscs, worms, spiders, and insects. Their breeding-habits are peculiar in that there is usually no union between the two sexes; the females seizing the packets of spermatozoa deposited by the males, and conveying them to their own reproductive chambers. While some species lay eggs, in other cases the eggs are hatched within the bodies of the female parent, and the tadpoles born alive, sometimes in a highly advanced stage of development. In the case of the common salamander, during the breeding-season the male enters the water first, and is followed shortly afterwards by the female, who gives birth to her tadpoles; but in the Alpine salamander, the young are born on land. The water-newts, on the other hand, lay eggs which are attached to the stems and leaves of aquatic plants. The majority of the terrestrial forms pass the earlier stages of their existence in the water, not leaving this element till their lungs have become fully developed. In the tadpole-stage all the members of the order are remarkably alike; and this resemblance forbids any wide separation of species like the olm, in which the external gills are retained, from the true newts and salamanders, in which these appendages are lost at an early period.

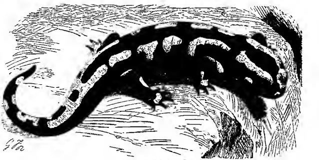
Although some of the larger kinds prey upon small fish, none of the newts and salamanders can be said to be harmful to man; while the terrestrial forms are defended against all foes, except fish, frogs, and snakes, by the poisonous secretion exuded by the glands of their skins; water-newts are, however, devoured by aquatic birds and mammals. The reputed noxious characters of the common salamander, and its alleged immunity to the effects of fire, are, of course, purely fabulous. The existing members of the order are divided into four families.

THE SALAMANDER TRIBE.

Family *SALAMANDRIDÆ.*

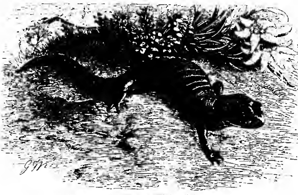
Comprising the typical members of the order, this family is specially characterised by the absence of gills in the adult condition, the presence of upper jawbones or maxillæ, as well as of teeth in both the upper and lower jaws, and likewise by the development of distinct eyelids. The family, which includes by far the great majority of the order, is divided into four subfamilies; the first of which is characterised by having the teeth on the palate of the skull arranged in two longitudinal series, diverging posteriorly, and inserted on the inner margin of two backwardly-prolonged processes of the palatine bones. The median parasphenoid bone on the base of the skull is devoid of teeth, and the bodies of the vertebræ are convex in front and concave behind.

Typical salamanders. The typical genus of the first subfamily (*Salamandrinæ*) is represented by three species, ranging from Central and Southern Europe to the Caucasus, Syria, and Algeria, of which the best known is the common spotted salamander (*Salamandra maculosa*). As a genus, these salamanders are characterised by the large and suboval tongue being free on the sides, and to a small degree also behind; by the palatine teeth forming two curved series; by the presence of four front and five hind-toes; and likewise by the nearly cylindrical section of the tail. The spotted species, which varies in length from 7 to 9 inches, may be recognised by the length of the tail being slightly less than that of the head and body, and still more readily by its brilliant black and yellow coloration. The head is depressed and nearly as broad as long; while the stout body is likewise somewhat depressed, without any crest along the middle of the back; and the short toes are devoid of any connecting webs. The smooth and shining skin is covered on the upper-parts with pores, from which exudes a viscid and acrid secretion, having decidedly poisonous properties. The yellow markings on the head, back, and tail are arranged in two longitudinal series broken up into more or less irregularly-shaped patches The species is an inhabitant of Central and Southern Europe, Algeria, and Syria; and is the one which from time immemorial has been dreaded, not only on account of its undoubtedly poisonous properties, but likewise owing to the extraordinary superstition that if thrown on a fire it would not be consumed. Frequenting moist and shady spots, either in the mountains among rocks, or in valleys and forests, the salamander passes the daytime in a kind of torpid condition, only issuing forth from its hiding-places among stones or roots of trees either during rainy weather or after nightfall; its skin being quickly dried up if exposed to the direct rays of the sun. Its movements on land are slow and sluggish, its gait being a crawl with a marked lateral movement; but in water the creature swims strongly, mainly by the aid of its tail. Although frequently found in the neighbourhood of its fellows, this salamander can scarcely be termed a sociable creature; and it is only during the breeding-season that the two sexes live in company. From the slowness of its own movements, it is only slow-moving creatures such as snails, worms, and beetles that the salamander can capture for its food; although it is stated to occasionally kill small vertebrates. Generally a large quantity of food is consumed, after which there is a long fast, sometimes lasting for as much as a month. During the pairing-season, which is in April or May, both sexes betake themselves to the water, when the females collect the spawn deposited by the males. Although the young are usually born alive, it occasionally happens that eggs are laid by the female, from which the young almost immediately make their escape. The number of tadpoles produced at a birth is very large, as many as fifty eggs being frequently found within the body of the female: while an instance is on record where upwards of forty-eight young were born within four-and-twenty hours. More generally, however, from



SPOTTED SALAMANDER (nat. size).

eight to sixteen, and less commonly from twenty-four to thirty tadpoles make their appearance into the world during a period of from two to five days. Generally all these are in an equally advanced state of development; but sometimes in captivity both eggs and tadpoles are produced simultaneously, the former being translucent and showing the young tadpoles curled up within them. The tadpoles, which are generally produced in clear, running water, are blackish grey in colour with a more or less well-marked greenish tinge; but there are small golden spots on the back, which gradually increase in size with advancing age. The skin also gradually becomes less shining and smooth, while at the same time the gills shrink, till about August or September the young salamanders quit the water for a terrestrial life. A few may, however, remain till as late as October. It is remarkable that the young salamander is rather inferior in size to the tadpole in the latest stage of development; and it is not yet known for how long a period it continues to grow after leaving the water. In aquaria salamanders develop more quickly, and have been known to leave the water within three weeks. The winter sleep generally takes place in moss-lined crannies, well protected from the frost, and may endure till the commencement of April.



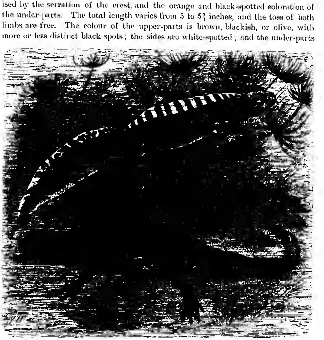
ALPINE SALAMANDER (nat. size).

Alpine Salamander. The Alpine, or black salamander (*S. atra*), inhabiting the Alps at elevations of from three to ten thousand feet, is a smaller animal than the last, from which it may be at once distinguished by its inferior dimensions. Ranging from the Alps into Styria, Carinthia, and some of the mountains of Würtemberg and Bavaria, this species inhabits moist woods or the banks of mountain-streams, where it is generally found in small family-parties, which conceal themselves after the manner of their kind beneath stones and moss, or at the roots of the Alpine rose. Although resembling the spotted salamander in producing living young, this species differs in that never more than two are born at a time. The most remarkable circumstance connected with the reproduction of the species is, however, that from thirty to forty eggs are found in the oviducts of the females, out of which only one develops in each oviduct, at the cost of the remainder, which form a glutinous mass surrounding the developing egg, and in which the liberated tadpole can afterwards freely move. There are also some fifteen unimpregnated eggs in each oviduct, which serve as the food of the newly-hatched tadpole. The tadpole, which does not attain its full size till after birth, lies in the oviduct of the female with its tail curled, but is capable of moving and even turning round. Its gills are of unusual length, being nearly half as long as the whole body; but before birth these shrivel up and are represented by mere knobs, so that the whole of the tadpole stage is passed through within the maternal body. Tadpoles that have been taken from the oviduct before completing their development will, however, live in water like those of the other species, thus proving that the species originally went through a temporary aquatic existence. Although the two young salamanders are generally born at the same time, occasionally one develops more rapidly than the other, so that there may be an interval of several days between the births of the two. At the pairing-seasons these salamanders enter the water for a few hours, but are otherwise purely terrestrial. The third representative of the genus is the Caucasian salamander (*S. caucasica*), distinguished from both the others by the tail being longer than the head and body. In colour this species is black, with irregular rows of round yellow spots down the back.

Spanish Salamander. This species (*Chioglossa lusitanica*) is the sole representative of a genus distinguished from the last by the tongue being supported on a median protrusile pedicle, and consequently free everywhere except on the front half of the median line. Considerably smaller than the spotted salamander, this species is dark brown in colour, rather lighter above than below, with two broad reddish golden bands along the body, separated from one another by a dark line along the middle of the back. It inhabits the north-western districts of Spain and the whole of Portugal.

Newts. The newts (genus *Molge*) form an extensive group, of aquatic habits, spread over Europe, Northern Asia, and North America, and are the only members of the order found within the limits of the British Islands. Having the same number of toes as the salamanders, they are distinguished by the highly compressed and rudder-like tail, as well as by the frequent presence of a fin-like crest down the middle of the back, which often attains a special development in the males during the breeding-season. With the exception of the crested newt, the skull differs from that of the salamanders by the presence of a ligamentous or bony arch connecting the frontal with the squamosal bone; and the palatine teeth form two nearly straight or slightly curved series. The tongue is free along the sides, but may be either attached or more or less free behind. The genus may be divided into two main groups, according to the presence or absence of a crest down the middle of the back of the males; and each of these may be further subdivided according to the characters of the so-called fronto-squamosal arch.

Crested Newt Belonging to the group in which the males are provided with a dorsal crest, this species (*M. cristata*) differs from all the others in the absence of a fronto-squamosal arch to the skull, while it is further characterised by the serration of the crest, and the orange and black-spotted coloration of the under parts. The total length varies from 5 to 5¾ inches, and the toes of both limbs are free. The colour of the upper-parts is brown, blackish, or olive, with more or less distinct black spots; the sides are white-spotted; and the under-parts orange, with black spots or marblings. During the breeding-season the head of the male is marbled with black and white, and there is a silvery band along the sides of the tail: while in the female the under surface of the tail is uniformly orange. The toes are yellow with black rings. An inhabitant of Britain, this species is spread over the greater part of Europe, extending as far north as Sweden, but unknown in Italy, and ranging eastwards to Greece, Turkey, and Russia. Not improbably Blasius's newt (*M. blasii*), from North-Western France, is a hybrid between the present and the next species, having the form and coloration of the former, but the fronto-squamosal arch of the latter.



MALE AND FEMALE OF MARBLED NEWT (nat. size).

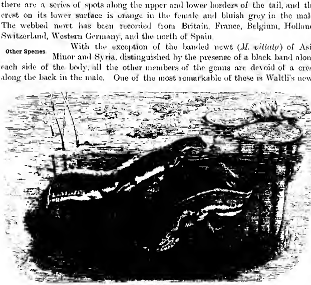
Marbled Newt Of the other European species, one of the handsomest is the marbled newt (*M. marmorata*) from France, Spain, and Portugal, of which a male and female are represented in the illustration on p. 295. Having a ligamentous fronto-squamosal arch to the skull, this species is specially distinguished by the smooth dorsal crest of the male, and by the under-parts being generally dark with white dots. The total length is about five and a quarter inches. In general colour the upper-parts are green with black marblings; the crest of the male being ornamented with black and white vertical bars, while in the female an orange streak runs down the middle of the back. The sides of the tail have a silvery white band, most distinctly marked in the male during the breeding-season; the under-parts are brown or greyish, with more or less distinct darker spots, and dotted with white; and the green toes are marked with black rings. Rare in France, this species is common in Spain and Portugal; and it lives in ponds and streams only in the early spring, spending the remainder of the year on dry land.

Alpine Newt. The next species for notice is the Alpine newt (*M. alpestris*) represented in the illustration on p. 289, which differs from the last by the much lower dorsal crest of the males, and likewise by the uniformly orange colour of the under-parts. In size it is a comparatively small species, varying from three and a quarter to four inches in length. In colour the upper-parts, which may be either uniform or with darker marblings, vary from brown, greyish, to purplish; the sides have a series of small black spots on a whitish ground, beneath which, in the male during the breeding-season runs a sky-blue band; the crest on the back and tail is white with round black spots; the throat is frequently dotted with black; the under-parts are uniform orange or red; and the lower edge of the tail of the female is orange spotted with black. The Alpine newt inhabits France, Belgium, Holland, Germany, Switzerland, Austria, and the north of Italy.

Common Newt. A fourth European representative of the genus is the small common newt (*M. vulgaris*), which belongs to the same group as the preceding, and is distinguished by the festooning of the dorsal crest, the lobate hind-toes of the male and the black-spotted under-parts. Abundant in almost every English pond and ditch, where the water is sufficiently clear, this species ranges all over Europe, with the exception of the south of France, Spain, and Portugal, and is likewise widely distributed in temperate Asia. It measures about three and a quarter inches in length, and has a nearly smooth skin. The upper-parts are brown or olive in colour, with darker spots, larger and more rounded in the male than in the female; the head is marked with five longitudinal dark streaks; the under-parts are yellowish, with a median orange or reddish zone, and marked with black spots in the male, and dots of the same in the female. In the latter the lower edge of the tail is uniformly orange, whereas in the male it is red, bordered with blue and interrupted by vertical black bars.

Webbed Newt. The last of the European species we can notice at length is the webbed newt (*M. palmata*), distinguished from all the preceding by the bony fronto-squamosal arch to the skull, and likewise by the webbed hind-toes of the male. This is the smallest species yet noticed, its length not exceeding three inches. The colour of the upper-parts is brown or olive, with small dark spots on the body and longitudinal streaks on the head. In the male there are also minute brown speckles on the head; and the dorsal, as well as the upper part of the caudal crest, together with the hind-feet, are blackish. Except for a median orange zone, the under surface is uncoloured, although there may be a few small blackish dots; there are a series of spots along the upper and lower borders of the tail, and the crest on its lower surface is orange in the female and bluish grey in the male. The webbed newt has been recorded from Britain, France, Belgium, Holland, Switzerland, Western Germany, and the north of Spain.

Other Species. With the exception of the banded newt (*M. vittata*) of Asia Minor and Syria, distinguished by the presence of a black band along each side of the body, all the other members of the genus are devoid of a crest along the back in the male. One of the most remarkable of these is Waltl's newt



MALE AND FEMALE OF COMMON NEWT (nat. size).

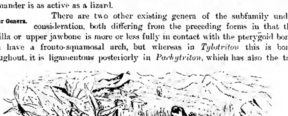
(*M. waltlii*), from Spain, Portugal, and Tangiers, distinguished by the elongation of the ribs, which in some instances actually perforate the skin, so as to form a row of sharp points on each side of the body. In a fossil state the genus has been recorded from the lower Miocene paper-coal deposits near Bonn.

Habits. Since the general habits of all newts are very similar, one account will serve for the entire group; but it must be remembered that whereas the whole of them are aquatic during the breeding-season, at the close of that period some species leave the water and live for the rest of the summer on land; while nearly all seem to pass some portion of the year out of the water. Newts generally prefer clear and running water, with plenty of aquatic plants on which to deposit their eggs. On land they are somewhat awkward and slow, but in water they swim with great rapidity by the aid of their oar-like tails, their hind-legs being pressed close to the sides of the body; their mode of progression being thus exactly the opposite to that of a frog. They often stand upright in the water when coming to the surface to breathe, after which they will sink to the bottom with a snake-like movement in search of prey. When on land, they seek shelter beneath stones and roots, or in holes in the ground, and in such situations often undergo their winter sleep, although such as live in deep water pass the cold season of the year in a kind of torpor at the bottom. All newts are carnivorous or insectivorous, and the crested newt feeds largely on the tadpoles of the common frog, while the larger species will prey on the smaller members of their own genus. Although there is considerable difference in the spawning-time of the various species, the eggs are generally deposited during May or June, the female laying each egg singly on the edge of the leaf of some water-plant, which is folded together by her hind feet, and thus held by the viscosity of the egg. In the course of a few days after its deposition, the white embryo assumes an elongated form within the egg; and soon it is seen to be folded upon itself, with the gills well developed, and in advance of them a pair of lobes by which the liberated tadpole affixes itself to aquatic plants. When about a quarter of an inch in length, and while the gills are still simple, the tadpole bursts its envelope; the front-limbs being represented merely by a pair of small knobs behind the gills. When hatched, it swims about in an aimless kind of way till it strikes against some object to which it can easily attach itself, and after a short time starts on another voyage. Development now proceeds apace, and in the course of two or three weeks the tadpole will have attained a length of about half an inch, while the gills will have become elegantly branched, and the fore-limbs well developed. At this period the eyes assume their permanent character, and the mouth has become terminal, while the lobes for attachment to plants are well-nigh absorbed. Still later the front feet, which had previously been only digitated, acquire four distinct toes, and the hind-limbs make their appearance and gradually assume their full proportions; but the gills have become still more complex. From this date the latter appendages gradually diminish in size, and shrivel, while the lungs are at the same time developed, until finally, about the latter part of the autumn, the creature has completed its metamorphosis and passed from the condition of a fish to that of a reptile. Although in most cases newts shed their skin piecemeal, in the crested newt it has been observed to be cast entire.

Spectacled Salamander The presence of only four toes to each foot, and of a bony fronto-squamosal arch to the skull, are the most distinctive features of the little spectacled salamander (*Salamandrina perspicillata*) of Italy, the sole representative of the genus to which it belongs. It is, however, further distinguished by its slender form, and also by its somewhat compressed and rapidly tapering tail, furnished both above and below with a longitudinal keel, as well as by the palatine teeth being arranged in two parallel series diverging posteriorly. The tongue is very similar to that of the genus *Chioglossa*. Reaching from rather more than 3 to nearly 4 inches in length, this pretty little salamander has a warty skin, and is generally black on the upper-parts, although there is a triangular or chevron-shaped yellow mark on the top of the head. Beneath, the chin is white, the throat black, and the rest of the under-parts white, usually marked with black spots; the lower surface of the tail and adjacent part of the body is, however, bright carmine.

The tarantolina, as this salamander is termed in Italy and Sardinia, inhabits cool, shady spots on the flanks of the mountains, where it feeds chiefly upon ants and spiders, and is active at all seasons of the year, having been seen abroad even in January. Although it appears that the pairing takes place on land, the females resort to the water in March to deposit their eggs, those that are the first to arrive taking the best places, such as sheltered corners of rock, where the spawn will be less likely to be washed away by floods. The young are hatched in about three weeks, and generally leave the water in June. In its movements on land this salamander is as active as a lizard.

Other Genera. There are two other existing genera of the subfamily under consideration, both differing from the preceding forms in that the maxilla or upper jawbone is more or less fully in contact with the pterygoid bone. Both have a fronto-squamosal arch, but whereas in *Tylotriton* this is bony throughout, it is ligamentous posteriorly in *Pachytriton*, which has also the tail cylindrical at the base, instead of compressed throughout. The former genus, in which the skin is extremely warty, is represented by one species from Siam and the Eastern Himalaya, and a second from the Liu Kiu Islands, while the latter is known only by a single Chinese form.



SPECTACLED SALAMANDER (nat. size).

Axolotls. Although properly speaking the term axolotl applies only to the permanent larval form of the Mexican representative of the genus *Amblystoma*, it will be found convenient in practice to make it include all the members of that group, whether mature or immature. Together with certain other genera, *Amblystoma* constitutes a second subfamily (*Amblystomatinæ*) distinguished from the *Salamandrinæ* by the teeth on the palate forming a transverse or posteriorly converging series, and being inserted on the hinder portion of those bones known as the vomers; as well as by the bodies of the vertebræ being cupped at each end. The type genus is specially characterised by the palatal teeth forming a nearly straight or angulated series, not separated by a space in the middle line; and likewise by the radiating folds of skin on the tongue, which are oval or nearly circular in form, with the sides completely and the front partially free. There are five hind-toes, and the tail is more or less compressed. Represented by a number of North American species, one of which ranges as far south as Mexico, the genus has also one Asiatic member, inhabiting the mountains of Siam, probably at a great elevation.

The majority of axolotls pass from the tadpole to the salamander stage in the ordinary way, but this is not the case with the Mexican race of the Mexican axolotl (*A. tigrinum*), which likewise extends over a large area in the United States. The adult form is shown in our second illustration; and in this condition the head is large and depressed, and has a broad and blunt muzzle, the limbs being stout, with short toes, and the rather long tail distinctly compressed, and

LARVAL STAGE OF MEXICAN AXOLOTL ([illegible] nat. size).

keeled above and below near the extremity. The shining skin is finely granulated, and the general colour brown or blackish, with more or less numerous yellow spots, which may be arranged in transverse bands. In the United States, we believe, the transformation from the larva to the adult goes on in the ordinary manner; but the case is very different in Mexico. The city bearing that name is, as our readers are doubtless aware, surrounded by an extensive lake; while the country itself is characterised by its extreme dryness. In this lake dwell the creatures represented in our first illustration, which are known to the natives by the name of axolotl. It will be seen from this figure that they resemble the tadpole stage of ordinary salamanders and newts in having large branching gills, and a deep rudder-like tail; and the natural conclusion would be that they are larval forms. However in the Mexican lakes, the axolotls remain permanently in the water, retaining their gills throughout life, and laying eggs, as if they were adult; and it was consequently long considered that they belonged to a type with persistent gills. It was not indeed, until the year 1865, that light was thrown on the history of these remarkable creatures by six examples which had been living for more than a year at Paris. These comprised five males and one female, and in the middle of February the latter began to lay eggs which in the course of a month hatched into tadpoles like their parents. In the following September the gills and crest of the tail of one of these began to shrivel, while the head increased in size, and yellow spots made their appearance upon the dark skin. Towards the end of the same month, and in the early part of October, similar changes took place in the others, and soon afterwards the whole four assumed the appearance of the salamander, which had been previously described as *Amblystoma tigrinum*. Subsequently experiments were made with other young axolotls by placing them in a glass vessel filled with water, but with rocks at one end, so that the creatures could creep out and expose themselves to the air as much as they pleased. After a day's interval the amount of water in the vessel was diminished and almost immediately the gills of the axolotls began to shrink, and in the course of time, during which they dwelt chiefly in damp moss, the creatures gradually developed into air-breathing salamanders. It has been inferred from these remarkable experiments that the Mexican axolotl, like the other members of the genus to which it belongs, originally went through the normal series of transformations; but that, owing to the dry nature of the country it inhabits, it has acquired the habit of retaining the larval condition permanently. From its being able to breed in this state, it may further be inferred that the tadpole stage was

ADULT OF MEXICAN AXOLOTL (⅔ nat. size).

originally the permanent condition of all members of the order, and that the salamander stage is a later development.

Other Genera. There are six other genera, belonging to the subfamily *Amblystomatinæ*, of which *Hypnobius* is represented by several Japanese species. *Salamandrella*, distinguished by having only four hind-toes, is a Siberian type, with two species; *Onychodactylus*, which may be recognised by its black claws, is known by one species from Japan; while *Ranodon*, from Eastern Siberia and North-Eastern China, *Batrachyperus* from Moupin in Tibet, and the Californian *Dicamptodon*, all of which have the palatal teeth arranged in two arches, with their convexity forwards, and separated by a wide space in the middle, are likewise respectively represented by a single species. The two remaining subfamilies, which are exclusively American, can receive only very brief notice. In the first of these (*Plethodontinæ*) the series of palatal teeth is transverse and situated on the hinder part of the vomers; while there are also teeth on the parasphenoid bone; the bodies of the vertebræ being cupped at both ends. Of the five genera, *Plethodon*, with the tongue attached along the middle line to the anterior margin, and five hind-toes, is North American, where it is represented by several species. On the other hand, the large genus *Spelerpes*, which has the tongue attached only by a central pedicle, and all its edges free, ranges into Central America and the West Indies. The fourth subfamily, *Desmognathinæ*, differing from the last by the bodies of the vertebræ being cupped behind and convex in front, is represented only by *Desmognathus* from North America generally, and *Thorius* with one Mexican species.

THE FISH-LIKE SALAMANDERS

Family *AMPHIUMIDÆ.*

The members of this family, which, for want of a better name, may be collectively designated by a translation of their German title, *fischmolche*, differ from the *Salamandridæ* in the absence of eyelids. The bodies of their vertebræ are always cupped at both ends. They are all characterised by the weakness of the limbs in comparison to the body, and the wide separation of the front from the hinder pair. They live chiefly or entirely in the water, and breathe by means both of lungs and internal gills in the adult state. Only three genera are known, the first two of which are so closely allied that it is question whether they are really entitled to rank as distinct.

Giant Salamander. The earliest record that we have of this family is a skeleton from the upper Miocene of Oeningen in Basle described by Scheuchzer in the year 1726, under the name of *homo diluvii testis*, the learned doctor believing that he had to do with a human skeleton, which, like all fossils at that time, was considered to have been buried by the Noachian deluge. This fossil species, which was fully as large as the existing giant salamander, together with a smaller extinct species from lower Miocene strata near Bonn, probably belong to the same genus. The giant salamander (*Megalobatrachus maximus*) was first discovered in 1820 by Siebold in the rivers of Japan, but has been subsequently obtained from China. As a genus, it is characterised by having four front and five hind-toes, the absence of a gill-opening, and the presence of two internal gill-arches.

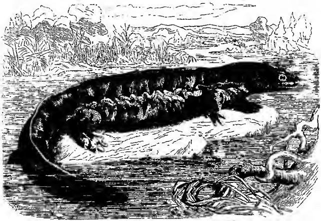
GIANT SALAMANDER ($\frac{1}{5}$ nat. size)

The tongue covers the whole of the floor of the mouth, to which it is completely adherent; while the palate has a curved series of teeth on the vomers, parallel to those on the margin of the upper jaw. In form the giant salamander is very stoutly built; the head being very large, wide, and flattened, with the muzzle regularly rounded, the small nostrils situated near the extremity, and the eyes very minute. The body is likewise broad and depressed; the legs and toes are short, the outer ones, as well as the outer side of the hind-leg, having a membranous fringe; and the short tail is strongly compressed, with a fin above and below, and its tip rounded. The skin, which forms a thick fold along each side of the body, is very warty, especially on the head; and the general colour is brown with black spots, becoming lighter on the upper-parts. Although the ordinary length of this salamander is about 35 inches, it is stated at times to grow to as much as 44 inches.

Originally purchased by Siebold in the market of Nippon, the giant salamander is now ascertained to inhabit not only the mountain streams of that island, but likewise those of several parts of the Japanese mainland, as well as of Western Central China. Nowhere very abundant, the creature generally frequents the upper courses of small mountain-streams at elevations of from seven hundred to five thousand feet above the sea-level; some of these streams being not more than a foot in width, and completely covered over with grasses and other herbage. The water is clear; and usually while the full-grown salamanders curl themselves round masses of rock in the bed of the stream, the younger ones live in holes. Except in search of food, which consists of worms, crustaceans, fish, and frogs the animals do not leave their hiding-places, and then only at night, while they never venture on land. In confinement they are extremely slow and sluggish in their movements, only exhibiting any marked activity when they rise to snap at a worm or other tempting morsel. In spite of its large size, the female lays very minute eggs, which are generally deposited in August and September. The smallest young yet observed had a length of about 6 inches, and in every respect resembled the adult. Probably however, at an earlier stage of development, external gills were present; and indeed, in an illustrated Japanese book, the young of the giant salamander is represented with these appendages. Further evidence of this is afforded by the circumstance that young specimens have been taken in which the gill openings were retained. The first two living examples were brought to Europe in 1829 by Siebold, and were fed on fresh-water fish brought from Japan, but when these began to fail, the male devoured his unfortunate partner. When suitable food was procured, the male, however, flourished and increased rapidly in size, surviving till the year 1881, when it died in Amsterdam.

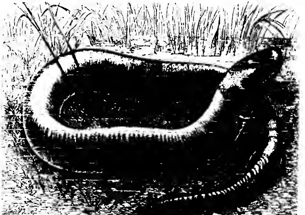
Hell Bender Under this euphonious name is designated in its native country the Mississippi salamander (*Cryptobranchus lateralis*), which differs from its Asiatic cousin by the presence of a gill-opening, at least on the left side of the neck, and likewise by the presence of four pairs of gill-arches, and by the anterior border of the tongue being free. In general form this salamander closely resembles its larger relative; the skin being porous and rather smooth, and the head covered with scattered wart-like tubercles. The colour is brown or greyish, with darker blotches, but the tips of the toes are yellowish. In length this species, which is the sole representative of its genus, reaches about 16 or 17 inches; and it inhabits all the tributaries of the Mississippi, and ranges into North Carolina.

In these streams it crawls or swims in a sluggish manner, seldom leaving the water, although it can exist on land for twenty-four hours or so at a stretch, feeding on crustaceans, worms, and fish, and being not unfrequently taken on the angler's hook. From the circumstance that the tadpoles have never been observed, it would seem that the larval stage must be of very short duration; and the only thing known about the development of the species is that the eggs are of relatively large size. Although perfectly innocuous, the hell-bender is regarded by American fishermen as a most noxious and poisonous reptile. It was first brought alive to Europe in 1869, since which date it has been frequently exhibited; and if fed on meat or the heads of fish will rapidly increase in size, although it appears to voluntarily undergo long fasts. While in the water it has been observed to make the air from its lungs pass over the gills, with the apparent object of more fully oxygenating the blood in the latter.



HELL-BENDER, OR MISSISSIPPI SALAMANDER (⅓ nat. size).

Three-Toed Salamander. The eel-like or three-toed salamander (*Amphiuma means*) represents another North American genus, ranging from the Mississippi to South Carolina, and distinguished by its extremely elongated and eel-like form, and the small size of the limbs, each of which terminates in three or two minute toes. The tongue is indistinctly defined, covering the whole of the floor of the mouth, to which it is everywhere adherent; there is a gill-aperture on each side of the neck, and four internal gill-arches are present. The head is relatively small, with a rather long and narrowing muzzle, at the extremity of which are the small and widely-separated nostrils; the eyes are likewise minute; the lips are unusually thick and fleshy; and the short compressed tail is keeled superiorly. The smooth and slimy skin is of a uniform blackish brown colour, although rather lighter below than above. In total length, full-grown examples measure about 31 inches. From the difference in the number of the toes it has been thought that there are two species, but since the two-toed and three-toed forms are in other respects similar, it seems preferable to regard them as varieties or local races of a single species. These salamanders are inhabitants of muddy waters, frequently burying themselves in the mud at the bottom, in one instance to the depth of a yard or more, in thick clayey mud of the consistence of putty, in which they burrowed like worms. They also frequent the irrigation channels in rice-fields, while they occasionally venture



THREE-TOED EEL-LIKE SALAMANDER (nat. size).

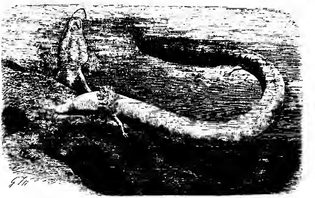
on land. Their food comprises fresh-water mussels, fish, beetles, other insects, and crustaceans. Beyond the fact that the female lays eggs, in which the tadpole lies coiled up until it attains several times the length of its chamber, little is known as to the breeding-habits of this species.

THE GILLED SALAMANDERS

Family *PROTEIDÆ*.

Represented only by the curious olm of the subterranean waters of Carniola and other parts of Europe and by an allied genus in North America, the gilled salamanders take their title from the permanent retention of external gills, on which account they may be regarded as some of the lowest representatives of the order. In addition to this primary feature, they are characterised by the absence of the upper jawbone or maxilla, although the premaxilla is present, and, like the lower jaw, furnished with teeth. There are no eyelids, and the bodies of the vertebræ are cupped at both extremities. There are differences in the external form of the two representatives; the olm being a long, snake-like creature with small limbs, whereas the American species resembles a salamander.

Olm. Known for more than a couple of centuries, the remarkable creature to which Oken gave the name of olm is the sole representative of its genus, and is technically known as *Proteus anguineus*. From its American ally it is distinguished by its elongated snake-like body and small and widely



THE OLM (⅔ nat. size)

separated limbs, of which the front pair are provided with three and the hinder with only two toes. The eyes are concealed beneath the skin, the small tongue is free in front and the palatal teeth are small and arranged in a double series. In the typical form from Carniola the head is elongate, with a long and narrow muzzle, truncated at the tip: the mouth being small, with large lips. The short and much compressed tail is provided with a fin, and rounded or bluntly pointed at the tip. The smooth skin is marked by twenty-six or twenty-seven grooves, corresponding to the ribs, and is uniformly flesh-coloured, with coral-red gills. In a variety from Dalmatia the snout is longer and narrower, and the number of costal grooves only twenty-four: while in a second variety, inhabiting Carinthia, the whole form is stouter, the head shorter, with a rounded muzzle, and the number of costal grooves twenty-five. There is also a certain variation as regards colour, apparently largely depending upon the amount of light to which the creatures have been exposed; some examples being reddish brown and others darker with bluish black spots. The usual length is about 10 inches.

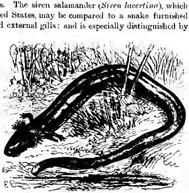
Totally blind, the olm is found solely in the subterranean waters of the caverns of the Alps of Carniola, Dalmatia, and Carinthia; and has long been an object of the greatest interest to naturalists. It has been thought that the waters in which the olm lives were all connected together underground, and that the creatures only came up during flood-time; but the great distance from one another of the various localities where they are found is somewhat against this view. It is, however, only when the subterranean waters are at their greatest height that the olms are captured by the peasants, by whom they are placed in glass jars, half filled with water and sold to tourists. In confinement, where they have been known to survive from six to eight years, they lie sluggishly all day at the bottom of their tank, only moving if a ray of light impels them to seek a darker corner. When in small vessels, where the water is not often renewed, they will frequently come to the surface to breathe, opening their mouths, and letting air pass through their gill-openings; but in deeper, or frequently changed water, they breathe entirely by means of their gills. Many experiments have been made, with the view of ascertaining whether the olm will, under any circumstances, lose its gills, but hitherto without result. In captivity the food of these amphibians consists of molluscs, worms, and the minute creatures to be found among the leaves of water-plants. In spite of having been kept for many years in captivity, it was not ascertained till 1875 that the olm lays eggs; and it was thirteen years later before any tadpoles were hatched in captivity. In April 1888, upwards of seventy-six eggs were laid by a single female; and after a period of three months developed into tadpoles. These were very similar to the adult, but the tail-fin extended three quarters down the back; the eye was larger, and apparently more susceptible to light; and the hind-limbs were in the form of small knobs.

Furrowed Salamander. A very different looking animal is the furrowed salamander (*Necturus maculatus*), of Eastern North America and Canada, which takes its name from the strongly-marked fold of skin on the throat. In addition to its shorter and more lizard-like form, and relatively longer limbs, it differs from the olm by having well-developed eyes, and four toes to each foot. The tongue is large, with the front border free; and the palatal teeth are large and form a single series. In colour the smooth skin is brown with more or less well-defined circular blackish spots, and lighter on the under parts than on the back. The total length is about a foot. An allied species (*N. punctatus*) inhabits the rice-fields of the Southern States. The food is similar to that of the allied forms, and in winter these salamanders seek protection from frost by burrowing deep in the mud. They come at times to the surface to breathe, and will even venture on land; but they chiefly respire by means of their gills, and if the latter become entangled, they are carefully rearranged by means of the fore-foot.

TWO-LEGGED SALAMANDERS.

Family *SIRENIDÆ*.

The sole representatives of this, the last, family of the Tailed Amphibians are the two-legged salamanders of North America, of which there are two species, arranged under as many genera (*Siren* and *Pseudobranchus*). While agreeing with the preceding family in the permanent retention of external gills, they are distinguished by the total loss of the hind-limbs, and likewise by the absence of teeth in the margins of the jaws. The siren salamander (*Siren lacertina*), which inhabits the South-Eastern United States, may be compared to a snake furnished with a pair of short fore-legs and external gills: and is especially distinguished by the presence of three pairs of gill-openings on the sides of the neck and the four-toed feet. The smooth skin is either uniformly blackish, or marked with small white dots, and the total length reaches to as much as 28 inches. The Georgian two-legged salamander (*Pseudobranchus striatus*), on the other hand, has only a single pair of gill-openings on the neck, and but three toes to the feet. These salamanders are stated to frequent swampy localities, especially pools of water beneath the roots of old trees, up the stems of which they will sometimes climb. A living example was received in England in 1825, where it lived till 1831. This specimen was fond of coming out of the water to rest on sand or among moss; and in summer ate worms, tadpoles, and various other small creatures, but became torpid from the middle of October till the end of April. That these salamanders can breathe entirely by means of their lungs, is proved by a specimen in an aquarium whose gills had been eaten off by a fish.



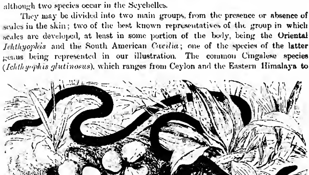
SIREN SALAMANDER.

THE CÆCILIANS OR WORM-LIKE AMPHIBIANS.

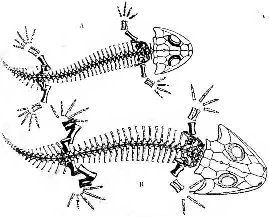
Order APODA.

The remarkable worm-like and blind amphibians forming this group are generally regarded as the representatives of a distinct order; although they are considered by Professor Cope to be merely a degraded branch of the Tailed Amphibians, to which they are allied through the fish-like salamanders. Be this as it may, the group is readily distinguished by the total absence of limbs, and the general worm-like appearance of the head and body; the tail being either rudimentary or wanting. In the skull the frontal bones are distinct from the parietals, but the palatines are fused with the maxillæ. As regards their reproduction, these amphibians differ from the newts and salamanders in that the two sexes come together in the ordinary manner. Some of them are peculiar in having overlapping scales imbedded in the skin, like fishes; and in all the eyes are either wanting, or are so deeply buried beneath the skin as to be entirely useless. The whole of the members of the group are burrowing in their habits; and in the adult state are completely terrestrial, laying eggs from which are developed gilled tadpoles that do not take to the water till some time after birth. The fourteen genera into which the group has been divided may all be included in the single family *Cæciliidæ*. Geographically, these amphibians are spread over the Indian region, Africa south of the Sahara, and Central and South America; but it is not a little remarkable that they are quite unknown in Madagascar, although two species occur in the Seychelles.

They may be divided into two main groups, from the presence or absence of scales in the skin; two of the best known representatives of the group in which scales are developed, at least in some portion of the body, being the Oriental *Ichthyophis* and the South American *Cæcilia*; one of the species of the latter genus being represented in our illustration. The common Cingalese species (*Ichthyophis glutinosus*), which ranges from Ceylon and the Eastern Himalaya to Sumatra and Java, inhabits damp situations, and usually burrows in soft mud. In some hollow near the water, the female (which measures about 15 inches in length) lays a cluster of very large eggs, round which she coils her body, and proceeds to brood them after the manner of a python. After the young are hatched out they remain in the egg-moss until they have lost their external gills, after which they take to the water, to lead for a time an aquatic life. During this stage of their existence the head is fish-like, with large lips, and the eyes better developed than in the adult; and they have a gill-opening on each side of the neck, and the tail is distinctly defined, much compressed, and furnished both above and below with fin. Of the group without scales, the genus *Gegenophis* is from Southern India, *Siphonops* from Tropical America, and *Typhlonectes* and *Chthonerpeton* from South America.



A WORM-LIKE AMPHIBIAN, *Cæcilia* (nat. size).

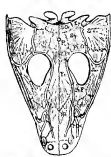


SKELETONS OF PRIMEVAL SALAMANDERS
Protriton, A, and *Pelosaurus*, B. (From Credner; much enlarged.)

CHAPTER III.

THE PRIMEVAL SALAMANDERS,—Order LABYRINTHODONTIA.

THE remaining amphibians are extinct, and form an order mainly characteristic of the upper Palæozoic and Triassic periods, but also lingering on into the Jurassic. They derive their name of Labyrinthodonts from the complex structure of the teeth of the higher forms; these displaying a peculiar pattern, caused by infoldings of the outer layer, which penetrate nearly to the centre of the crown in festooned lines. Most of these creatures have the general form of a salamander, with the front-limbs shorter than the hinder-pair, the latter having always five toes, although in the former the number may be reduced to two. Their most characteristic feature is, however, to be found in the structure of the skull, in which the bones are generally covered with a pitted or radiated sculpture, somewhat similar to that of crocodiles. From the accompanying figure of the skull of the mastodonsaur, it will be seen that the whole of the upper surface behind the sockets of the eyes is covered by a complete bony roof, extending continuously from the bone marked *P*, which immediately covers the brain-cavity to the sides of the hinder-part of the jaws (*QJ*), whereas in all the modern salamanders this region is more or less open. This roofed skull of the primeval salamanders presents an approximation to the earlier fishes; and a resemblance to that group is also shown by the paired supraoccipital bones (*So*), which in all the higher Vertebrates are fused together. Nearly all these salamanders are further distinguished by having the chest protected by three sculptured bony plates, one of which is central while the other two are lateral; the position of these plates being shown in our figure of the skeleton, where they are seen on the lower surface of the body, immediately behind the head, underlying the backbone and ribs. Besides this armour, some species had the whole of the under surface of the body protected by a series of bony scales, arranged in a chevron pattern; while in a few instances similar scales also invested the upper surface of the body. The majority of the members of the order had the vertebræ of the backbone in the form of simple doubly-cupped discs, similar to those of fishes; but in some of the most primitive types each vertebra consists of four distinct pieces, namely, a single basal piece (*i*), a pair of lateral pieces (*pl*), and a single arch and spine (*s*). Among some reptiles the basal piece remains between two adjacent vertebræ as the intercentrum; but in the higher forms the other elements coalesce. Since a similar type of vertebra occurs in certain extinct fishes, we have in this structure another bond between the latter and the primeval salamanders. Brief reference must also be made to the small aperture in the roof of the skull of the primeval salamanders in the bone marked *P*, since this corresponds to one in the skull of the tuatera lizard of New Zealand. In that animal the aperture overlies the rudiment of an eye sunk deep down in the brain and now totally useless, but probably functional in the tuatera's ancestors. The large size of the aperture in the primeval salamanders suggests that the central eye may still have been capable of receiving impressions of light, although we may have to go back to earlier forms before it was of any functional importance as an organ of vision. As in many existing amphibians, teeth frequently occur on the bones of the palate as well as in the margins of the jaws. Another feature of the skulls of many members of the order is the presence of what are called mucous canals in the bones of the upper surface, as shown both in the accompanying figure and in the one on p. 313; these canals also occurring in certain fishes. So far as can be ascertained, both external and internal gills generally disappeared in

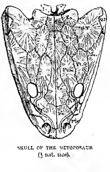


SKULL OF THE MASTODONSAUR, WITH THE SCULPTURE OMITTED

SO, supraoccipital; *Ep*, epiotic; *P*, parietal; *Sq*, squamosal; *ST*, supratemporal; *QJ*, quadratojugal; *Ju*, jugal; *Pf*, postfrontal; *PtO*, postorbital; *Fr*, frontal; *PrF*, prefrontal; *L*, lachrymal; *Na*, nasal; *Mx*, maxilla. The premaxilla has no letter. (About ⅙ nat. size.)

TWO VERTEBRÆ OF A PRIMEVAL SALAMANDER. *prz* is the anterior and *ptz* the posterior end.

the adult. Varying from the size of a small newt to that of a crocodile, the primeval salamanders are of especial interest to the evolutionist, as it is pretty certain that not only are they the descendants of primeval fishes, but that they are the ancestors both of the modern Amphibians and the extinct Anomodont Reptiles. And it is probable that Mammals have originated, either directly from them or from a lost group intermediate between them and the Anomodont Reptiles. They appear to have been spread over the whole globe, and they have been divided into several subordinal groups. Among these the highest are the true Labyrinthodonts, typically represented by the gigantic *Mastodonsaurus* and the somewhat smaller *Metoposaurus* of the Trias. These were crocodile-like animals, generally with disc-like vertebræ in the adult, the teeth more or less plicated, and the surface of the skull marked with sculpture and mucous canals. In the Permian *Archegosaurus*, the vertebræ were, however, of the complex primitive type. The Gilled Labyrinthodonts, as represented by *Protriton* and *Pelosaurus*, are a group of much smaller forms characterised by their barrel-shaped vertebræ, pierced by a remnant of the canal of the primitive notochord; short and straight ribs, articulating by a single head; simple teeth, and the absence of ossification in the occipital region of the skull, as well as in the wrist and ankle-joints, a further point of distinction being the development of internal gills in the young. The Permian and Carboniferous Snake-like Labyrinthodonts are characterised by the snake-like form of the body, and the apparent absence of limbs. The vertebræ were elongated and without spines, while the ribs were slender and barbed like those of fishes, and the teeth smooth and simple. Probably the external gills persisted throughout life. In Britain the group is represented by the small *Dolichosoma*, but *Palæosiren* of Bohemia is estimated to have been over 40 feet long. If these creatures prove to be the ancestors of the Worm-like Amphibians, it would show that the latter are distinct from the newts and salamanders. The Microsauria include small lizard-like forms, such as *Ceratocrpetum* and *Hylonomus* from the Carboniferous of Europe and Nova Scotia, which appear more highly organised than the preceding, and thus connect the Amphibians with the Beaked Reptiles. Their vertebræ are long and constricted, with traces of the notochord: the ribs are generally long, curved, and two-headed; the teeth have large central pulp-cavities, but no plications; the occiput is ossified; but the wrist and ankle are either ossified or cartilaginous; and in some cases the back is covered with bony scales. In several forms the bony scales on the under surface are so slender as to assume the appearance of abdominal ribs like those of the Beaked Reptiles.



SKULL OF THE METOPOSAUR (⅓ nat. size).

FISHES.

CHAPTER I

GENERAL CHARACTERISTICS,—Class **Pisces.**

ALTHOUGH in popular language lampreys are included among fishes, while until quite recently the lancelet was very generally placed by zoologists in the same class, it now seems preferable to make each of these the representative of a distinct class, and the true fishes can consequently be defined with greater precision. In this somewhat restricted sense fishes may be described as cold-blooded vertebrate animals, adapted for a purely aquatic life, and breathing almost invariably by means of gills alone. They have a heart consisting generally of only two chambers (three in the lung-fishes); the limbs, if present, are modified into fins; there are unpaired median fins supported by fin-rays, and, as in all the higher classes, the mouth is furnished with distinct jaws. The skin may be either naked, or covered with scales or bony plates. As a rule, fishes lay eggs; and the young do not undergo a distinct metamorphosis.

With the Tailed Amphibians the class is very closely connected by means of the lung-fishes, which are furnished not only with internal gills, but likewise with functional lungs, and during the early part of their existence with external gills; while these fishes also differ from the other members of the class in that the nostrils communicate posteriorly with the cavity of the mouth, as in the higher Vertebrates.

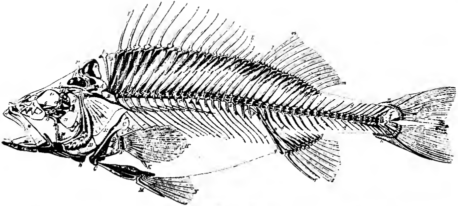
Although the bony fishes of the present day form a specialised side-branch, which has lost many of the characters common to the two classes, it will be evident that Fishes and Amphibians are very closely allied groups; the latter of which has been directly derived from the former. Geologically, fishes are older than any of the classes hitherto described, their fossil remains occurring in strata belonging to the upper part of the Silurian division of the Palæozoic epoch.

The form of a typical fish is so well known that it will be quite unnecessary to describe it; and it may be mentioned that this typical form, which is the one best adapted for progress through water, is very general amongst fresh-water fishes, although the eels constitute an exception in this respect. Much greater diversity exists, however, among the marine representatives of the class; and we may cite as extreme types a shark, a flat-fish, a ribbon-fish, and a globe-fish.

Classification. The structure of the skeleton, both external and internal, being of the utmost importance in the classification of fishes, it is essential that the attention of the reader should be more fully directed to this point than has been done in the case of the higher Vertebrates. It should first be mentioned that fishes are divided into four subclasses, namely, the Lung-Fishes or Dipnoi; the Chimæroids, or Holocephali; the Bony Fishes and Ganoids, or Teleostomi; and the Sharks and Rays, or Elasmobranchii. These may be further subdivided into orders as follows:—

1. Lung-Fishes—Subclass DIPNOI.
    (1) True Lung-Fishes—Order SIRENOIDEI.
    (2) Berry-Boned Fishes—Order ARTHRODIRA (extinct).
2. Chimæroids—Subclass HOLOCEPHALI.
3. Bony-Fishes and Ganoids—Subclass TELEOSTOMI.
    (1) Fan-Finned Fishes—Order ACTINOPTERYGII.
    (2) Fringe-Finned Ganoids—Order CROSSOPTERYGII.
4. Sharks and Rays—Subclass ELASMOBRANCHII.
    (1) Acanthodians—Order ACANTHODII (extinct).
    (2) Fringe-Finned Sharks—Order ICHTHYOTOMI (extinct).
    (3) True Sharks and Rays—Order SELACHOIDEI.

External Skeleton. In regard to the external skeleton, the most characteristic type takes the form of scales. When these overlap and their posterior border is entire, such scales are termed *cycloid*, but when serrated *ctenoid*. The external skeleton may, however, take the form of plates or granules, which in the chimæroids and sharks and rays are generally isolated, and have a structure precisely similar to that of teeth, consisting of a base of ivory or dentine capped with enamel. The so-called *ganoid* scales, like those of the bony-pike, are on the other hand, quadrangular, and often connected by a peg-and-socket arrangement; they are formed of true bone capped with an enamel-like substance termed *ganoin*, and true bone likewise occurs in the plates of the sturgeons. A series of specially modified scales, running along the sides of many fishes, constitute the so-called *lateral line*, which is partly connected with the supply of mucus; and certain large V-shaped scales on the borders of the fins of many extinct bony fishes are known as *fulcra*. The *fin-rays*, which also come under the designation of dermal structures,

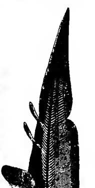


SKELETON OF PERCH.

1, frontal; 2, prefrontal; 3, ethmoid; 4, postfrontal; 5, basioccipital (concealed); 6, parasphenoid; 7, parietal; 8, supraoccipital; 9, paroccipital; 10, exoccipital; 11, alisphenoid (concealed); 12, mastoid; 13, squamosal; 14, orbitosphenoid; 15, presphenoid (concealed); 16, vomer (hidden by 19); 17, premaxilla; 18, maxilla, or upper jawbone; 19, 19', infraorbital ring; 20, nasal; 21, supratemporal; 22, palatine (concealed); 23, hyomandibular; 24, ectopterygoid; 25, entopterygoid; 26, quadrate; 27, metapterygoid; 28, opercular; 29, stylohyal (concealed); 30, preopercular; 31, symplectic; 32, subopercular; 33, interopercular; 34, dentary; 35, articular; 36, angular; 37, hyals (concealed); *a*, vertebræ; *b*, confluent tail-vertebræ; *c*, transverse processes; *d*, inferior arches and spines of tail-vertebræ; *e*, ribs; *f*, barbs of ribs; *g*, superior arches and spines of vertebræ; *h*, anterior interspinals; *i*, posterior interspinals; *k*, hard rays of anterior dorsal fin; *l*, hard, and *m*, soft rays of hinder dorsal fin; *n*, *o*, hard and soft rays of caudal fin; interhæmal spines; *q*, interspinals of anal fin; *r*, *s*, hard and soft rays of anal fin; *A*, post-temporal; *B*, supraclavicular; *C*, clavicular; *D*, coracoid; *E*, scapula; *F*, basals; *G*, *H*, rays of pectoral fin; *I*, *K*, postclavicular; *L*, pelvis; *M*, *N*, hard and soft rays of pelvic fin.

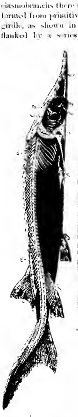
are shown in the skeleton represented on p. 316, and occur in both the median and paired fins, of which the names are also given in the same illustration. In the median fins the bases of these rays articulate with the *interspinal bones*, or, in elasmobranchs, with the *radial cartilages*. The first rays of the pectoral and dorsal fins may be developed into long spines, having the same structure as teeth.

Internal Skeleton. In the internal skeleton the backbone is divisible only into a trunk and caudal moiety. In the fringe-finned ganoid fishes the primitive notochord persists, although it may be partly surrounded by rudimental arches; while in the sharks and higher bony fishes the column is divided into segments, forming vertebræ with doubly-cupped bodies. In sharks and rays the arches and bodies of the vertebræ remain separate, but in the other groups they are fused together; in the tail, as shown in our figure of the skeleton of the perch, there is also an inferior arch and spine to each vertebra. In the more primitive fishes the notochord is continued to the hinder extremity of the body, where it is surrounded symmetrically by the rays of the caudal fin; this type, which is shown in the accompanying figure of the skeleton of an extinct fringe-finned shark, being termed the *fringe-tailed*, or *diphycercal*. Whereas in some fishes with this type of tail the fringes on the upper and lower portions of the caudal fin are of nearly equal depth, in others the lower fringe of rays becomes somewhat deeper than the others, and a further development of this inequality results in the partially forked or *heterocercal* tail of the modern sharks and sturgeons, where the end of the backbone is bent upwards into the longer superior lobe of the tail, the lower lobe of which is formed exclusively of rays. The lung-fishes and sharks have never advanced beyond one or other of these types; but the bony fishes and ganoids, which started with the primitive fringed lobate type, by a gradual shortening of the central part of the tail-fin, accompanied by an increasing development of the rays on its lower side, have evolved the completely forked or *homocercal* tail of the perch, in which, as shown in the figure, the backbone stops short of the fin-rays, and ends in an expanded, unsymmetrical extremity, from which these rays are given off in a fan-like manner, so as to produce an appearance of perfect symmetry in the whole structure.

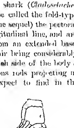


SKELETON OF EXTINCT FRINGE-FINNED SHARK, SHOWING DIPHYCERCAL TAIL. (From Fritsch.)

Turning to the limbs or paired fins, we find that while in the existing elasmobranchs there are no membrane bones (as the elements of the skeleton not formed from primitive cartilage are termed), in the higher bony fishes the pectoral girdle, as shown in the figure on p. 316, comprises a scapula and a coracoid, flanked by a series of membrane-bones, known as the *post-temporal*, *supra-clavicular*, *clavicular*, and *postclavicular*. The pelvis is generally absent, and is never highly developed. In all cases the basal and radial bones of the pectoral fins articulate directly with the pectoral girdle, so that there are no segments corresponding to the arm and fore-arm of the higher Vertebrates. In the paired fins the structure is very similar to that of the tail; and a similar transition from a fringed to a fan-like type may be traced as we pass from the primitive to the specialised forms. For instance, in the figure of the perch's skeleton on p. 316, we may notice that the paired fins are formed of a number of hard rays spreading out in a fan-like manner from a single point of origin; and the same general type obtains in the existing sharks and rays. In certain extinct sharks, like the one of which the skeleton is shown on p. 317, as well as in the lung-fishes and the fringe-finned ganoids, the pectoral fins have a long central lobe running for some distance up the middle, and completely covered with scales (where these are developed), while the rays of these fins form a kind of fringe radiating on all sides from the central lobe. The skeleton of such a fin, which is known as an *archipterygium*, consists of a long cartilaginous axis, composed of a number of joints, gradually decreasing in size from the base to the extremity, as shown in the figure on p. 319. From one or both sides of such joints there are given off a number of oblique smaller jointed rods terminating in the fine rays forming the free edges of the fins. How different is the structure of this fin from that of the higher bony fishes will be apparent by comparing the accompanying figure with that of the skeleton of the perch on p. 316. In the lung-fishes this primitive type of fin has persisted to the present day; in the sharks it has now totally disappeared; while among the bony fishes and ganoids, in the latter of which it was the universal type at the period of the Old Red Sandstone, it now only remains in a modified form in the bichir of the Nile, having been developed in the modern bony fishes into the fan-type. It may be mentioned that the latter modification of fin is obviously the one best adapted for quick-swimming fishes, the fringe-finned type partaking more of the nature of clumsy paddles, and being adapted for slowly-moving forms like the lung-fishes, which pass most of their time among the mud at the bottom of rivers.


SKELETON OF STURGEON, EXHIBITING HETEROCERCAL TAIL.

It must not be supposed, however, that even the fringed type is the most primitive form of fin known, since in an extinct armoured shark (*Cladoselache*) from the Carboniferous formation, we meet with what may be called the fold-type of paired fins. In these fishes (one of which is figured in the sequel) the pectoral and pelvic fins are placed far apart, but in the same longitudinal line, and are formed of a series of parallel cartilaginous rods arising from an extended base, and projecting at right angles to the body; the pectoral pair being considerably the larger. Assuming that fishes originally possessed on each side of the body a continuous fold of skin, strengthened by parallel cartilaginous rods projecting at right angles, this fold-type is exactly what we should expect to find in the evolution of pectoral and pelvic fins by the disappearance of a considerable portion of the original fold, and the development and basal contraction of the remaining moieties.



SKELETON OF PECTORAL FIN OF AN EXTINCT FRINGE-FINNED SHARK. (From Fritsch.)

Although the structure of the skull is of the highest importance in the classification of fishes, our remarks on this subject must be very brief. In the skulls of the higher bony fishes the original cartilaginous cranium, which persists in the sharks, is overlain by a number of membrane-bones, the names and position of which are indicated in the figure of the perch's skeleton on p. 316. Among these the *pterotic* and *sphenotic* are peculiar to the class, and there is always a large *parasphenoid* underlying the base of the skull. The intervention of the elements known as the *hyomandibular* and *symplectic* between the squamosal and the quadrate is unknown elsewhere, although it is by no means universal among fishes. Among other bones may be mentioned the *infraorbital ring* beneath the eye; as well as the *preopercular*, *subopercular*, *interopercular*, and *opercular*, collectively constituting the gill-cover or *operculum* of the bony fishes. In the *gill* (or *branchiostegal*) *membrane*, which joins with the gill-cover in closing in the gill-chamber, there may be developed a number of *gill* (or *branchiostegal*) *rays*: but these may be partially or entirely replaced by *jugular plates*, occupying the space between the two branches of the lower jaw. It will be unnecessary to mention by name the various bones constituting the *hyoid arch*, which is attached to the inner side of the hyomandibular by the *stylohyal*, and extends forwards to support the tongue; and it will suffice to state that behind this arch are situated the *branchial* or *gill-arches*, to the inner margins of which are attached the spine-like gill-rakers. In the lower jaw, or mandible, there is usually both a *dentary* and an *articular* piece; but an *angular*, and more rarely a *splenial* or *coronoid* element may likewise be developed.

Teeth.

The teeth of fishes present a greater degree of variation than is found among any other class of Vertebrates. While in some cases they may be totally wanting, in others they may be developed on all the bones of the mouth, and even on the hyoid bones and gill-arches; and they may be attached only to the membrane lining the cavity of the mouth. Frequently they are welded to the underlying bone or cartilage by a broad basis; but, as in the saw-fishes, they may be emplanted in distinct sockets. Usually the coating of enamel is very thin; and the ivory, or dentine, is more vascular than in the other classes. In rare instances the ivory may be penetrated by branching prolongations from the central pulp-cavity, as well as by similar infoldings from the exterior, thus producing a structure similar to that obtaining in those of the primeval salamanders. As a general rule the teeth are being constantly renewed throughout life, but in a few instances a single set persists.

Coloration. In beauty, variety, and changeability, the colours of fishes cannot be exceeded by those of any of the other vertebrate classes; metallic tints and almost all the colours of the rainbow being very commonly displayed; while the beauty of the coloration is often enhanced by the rapid changes it undergoes. In many cases the coloration is of a protective nature. An example of this is afforded by the colouring of the upper surface of many flat-fishes, such as flounders, which exactly harmonises with the tints of the sea-bottom on which they dwell; while another equally marked instance presents itself in the case of so-called pelagic fishes, like the mackerels and flying-fish, which live near the surface of the sea, and have the under-parts silvery white, and the back mottled with dark green and black. When viewed from below against the light sky such a fish is practically invisible, while it is equally inconspicuous when seen from above among the dark waters.

Soft Parts. The body of fishes is made up of a great lateral muscle on each side, divided into a number of segments corresponding with the vertebræ, and also separated into a dorsal and ventral moiety by a median longitudinal groove. On its surface the lateral muscle is marked by a number of white zigzag stripes, generally forming three angles, of which the middle one is directed forwards; these stripes being formed by the edges of the tendinous divisions between the segments. Generally the muscles are glistening white in colour; but in some instances they are "salmon-coloured," this tint being due to the colouring matter of the crustaceans on which such fish subsist, which is turned red by the action of the digestive fluids in the same manner as by boiling. The electric organs possessed by certain fishes are considered to be probably formed from specially developed muscles. With regard to the brain, it will suffice to say that it is of an exceedingly low type; and that the ear lacks the tympanum and tympanic cavity of the higher classes. In the bony fishes there occurs at the base of the brain-cavity a sac, often divided into two unequal-sized chambers, and each of which contains an ear bone, or *otolith*, of very dense structure. These otoliths, which are very constant in form in the different groups, frequently have scalloped margins and groove-like markings, formed by the ramifications of the auditory nerve. The tongue is frequently absent, and if present is of very simple structure and incapable of protrusion; and since fishes generally bolt their food without mastication, it is probable that they have little, if any, sense of taste. With regard to the digestive organs, it will suffice to mention that in the sharks, rays, and chimæroids the intestine for a large portion of its length is provided with a spiral valve, a similar structure occurring in the ichthyosaurian reptiles.

The gills of sharks, rays, and chimæroids are contained in pouches, usually five in number on each side; each pouch opening externally by a slit, and also communicating by a separate aperture with the pharynx. In the embryos filamentous gills protrude externally from the slits. The *spiracles* found on the top of the head in the groups mentioned are the external openings of a canal leading on each side into the pharynx, and represent what is known as the first visceral cleft in the embryo. In the bony fishes the gills, which are generally four in number, lie in one undivided cavity on each side of the head, supported by their gill-arches, and covered over by the gill-cover, which is open behind. In ordinary respiration the water is taken in by the mouth, and by a kind of swallowing action driven over the gills, after which it is expelled by the gill-opening. Allusion must be made in this place to certain organs known as false gills, or *pseudobranchiæ*. These are remains of a gill situated in front of the persistent ones, which was functional during embryonic life, but in the adult appears merely as a plexus of blood-vessels. Although the majority of fishes breathe in the manner indicated above, in many forms this is by no means the sole method of respiration. On this subject Day observes that respiration in fishes is carried out normally, either by their using the air which is held in water to oxygenate the blood at the gills, or "by taking in atmospheric air direct, which is employed at a special organ, where it oxygenates the blood, which can be returned for use into the general circulation without going through the gills. The true amphibious fishes respire by the latter method. No doubt we observe that fishes which normally oxygenate their blood solely at their gills do rise to the surface in very hot weather, when the water is foul or insufficiently charged with air, and take in air by the mouth; likewise we find that those which mainly take in atmospheric air direct by the mouth may, to a certain extent, be able to use their gills. If fishes having these two different modes of respiration are placed in a globe of water, across which a diaphragm of net is inserted below the surface, so as to prevent their obtaining access to the atmosphere, those of the class which oxygenate their blood at the gills are unaffected, whereas those which have accessory breathing-organs and take in air direct die from blood-poisoning."

One of the most characteristic organs of fishes is the air-bladder, which is a long sac filled with gas lying in the abdominal cavity, which may be either completely closed, or may communicate with the alimentary tract by means of a duct. As it is susceptible of compression, its usual function appears to be to regulate the specific gravity, or to change the centre of gravity of the fish; but in the lung-fishes it assumes the characters and functions of the lungs of the higher Vertebrates, to which, indeed, it corresponds.

Reproduction. Although in the few fishes which produce living young, as well as in the sharks and rays, an actual connection takes place between the two sexes, in the great majority of the class the ova are deposited by the female, after which they are fertilised by the male. The bony fishes lay numerous eggs which are of relatively small size and may be extremely minute, those of the eel being almost microscopic; but there is a considerable degree of variation in this respect. In the herring the number of eggs in the "roe" has been estimated at twenty-five thousand, and in the cod at over nine millions. Only in a cat-fish (*Aspredo*), where they are pressed into the skin of the under surface of the body, and a pipe-fish (*Solenostoma*), where they are carried in a pouch formed by the coalescence of the broad pelvic fins with the skin of the body, is the female known to take any care of her eggs after spawning. Among the bony fishes there are, however, several instances where the young are more or less carefully tended by the male parent; some, like the sticklebacks, building a nest, while others, like certain pipe-fishes, have an abdominal pouch in which the eggs are hatched. The eggs of sharks, rays, and chimæroids differ remarkably from those of bony fishes, being large in size, few in number, and laid singly instead of in masses. They are invested in a hard horny envelope, which is generally oblong in form, with the four corners produced, and frequently elongated into tendrils by means of which the egg is moored to some foreign substance. The males of these fishes are armed with organs known as *claspers*, which are partially ossified processes arising from the pubis, and are evidently connected with the function of reproduction. The young of many fishes differ markedly from the adult; and certain peculiar creatures with long ribbon-like bodies and small heads, for which the name of *Leptocephali* has been proposed, are believed to be the young of littoral fishes which have been carried out to sea, where they have undergone an altogether abnormal development. The changes which take place in the flat fishes during development may be more conveniently noticed under the heading of that group. Although male and female rays differ remarkably from one another in the structure of their teeth, while both in this group and in the sharks and chimæroids the males are distinguished by the possession of the aforesaid claspers, there is generally but little sexual difference among fishes. In the bony fishes, however, the females are larger than the males; among the cyprinodonts the difference between the two being occasionally as much as six times.

Tenacity of Life. Fishes exhibit a remarkable degree of difference in regard to their power of bearing changes from their normal environment. On this subject Dr. Günther writes that, "some will bear suspension of respiration—caused by removal from water, or by exposure to cold or heat—for a long time, whilst others succumb at once. Nearly all marine fishes are very sensitive to changes in the temperature of the water, and will not bear transportation from one climate to another. This seems to be much less the case with some fresh-water fishes of the temperate zone; since carp may survive after being frozen in a solid block of ice, and will thrive in the southern parts of the temperate zone. On the other hand, some fresh-water fishes are so sensitive to a change in the water that they perish when transferred from their native river into another apparently offering the same physical conditions. Some marine fishes may be abruptly transferred from salt into fresh-water, like sticklebacks; others survive the change when gradually effected, as many migratory fishes; whilst others, again, cannot bear the least alteration in the composition of the salt-water (all pelagic fishes). On the whole, instances of marine fishes voluntarily entering brackish or fresh-water are very numerous, whilst fresh-water fishes proper but rarely descend into salt water."

Distribution. The foregoing remarks lead naturally to the subject of the distribution of fishes; a subject which the limits of space compel us to dismiss with a few sentences. In the first place, we find that many marine fishes have a much less wide geographical distribution than might at first sight be expected; while on the other hand, we find families and genera, and even species, of fresh-water fishes inhabiting widely separated areas of the earth's surface. The primary division into fresh-water and marine fishes does not form such a sharply defined boundary as is commonly supposed; the transition being formed by the brackish-water types, species or even individuals of which can accustom themselves to live in either salt- or fresh-water. Then, again, we have certain essentially fresh-water fishes, like the salmon and some kinds of cat-fish, which pass a certain period of their existence in the ocean; while, on the other hand, some marine forms, such as sturgeons, periodically ascend rivers for the purpose of spawning. To a certain extent such habits will help to explain the occurrence of peculiar families of fresh-water fishes (such as the chromids of Africa, South America, and India) in widely separated areas, although this must probably be supplemented by dispersal from a common northern centre.

After the separation of the fresh-water and brackish-water types, the marine fishes are divided by Dr Günther into a littoral, a pelagic, and a deep-sea group, although here, again, no hard-and-fast lines can be drawn. The littoral or shore-fishes are those found in the immediate neighbourhood of land or sunken shoals, the majority living close to the surface, and very few descending as deep as three hundred fathoms. Their distribution is determined not only by the temperature of the surface-water, but likewise by the nature of the neighbouring land, and its animal and vegetable products; some of these fishes being suited to inhabit flat coasts with muddy or sandy bottoms, while others frequent rock-bound shores where the water is deep, and others, again, congregate round coral-reefs. Cod, rays, and flat-fish are well-known examples of this group. Pelagic fishes, such as tunnies, flying-fish, sword-fishes, and sun-fishes, inhabit the superficial layers of the open ocean, approaching the shores only by accident, or in some cases in search of food, or for the purpose of spawning. Dr. Günther writes that, "with regard to their distribution, they are still subject to the influences of light and the temperature of the surface-water; but they are independent of the variable local conditions which tie the shore-fish to its original home, and therefore roam freely over a space which would take a fresh-water or shore-fish thousands of years to cover in its gradual dispersal. Such as are devoid of rapidity of motion are dispersed over similarly large areas by the oceanic currents, more slowly than, but as surely as, the strong swimmers."

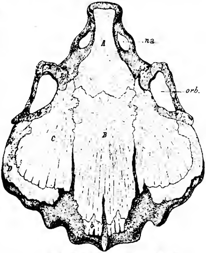
In marked contrast to the last are the deep-sea fishes, inhabiting the abyssal depths of the ocean, where they are undisturbed by tides or currents, and live for the most part in total darkness; their organisation, in consequence of the great pressure of the medium in which they live, preventing them from coming to the surface in a healthy condition. From the similarity in the physical conditions of the ocean-depths in all parts of the world, there seems no reason why a single species of deep-sea fish should not range from the Equator to the Poles; and the abyssal fauna is probably more or less nearly the same throughout the globe. These fishes belong for the most part to pelagic families, and especially to such types as are of nocturnal habits; and are characterised by their generally black or silvery colour, although in a few instances the fin-rays and certain filaments are scarlet. Writing of those fishes, Dr. Gunther observes that, "the organ of sight is the first to be affected by a sojourn in deep water. Even in fishes which habitually live at a depth of only eighty fathoms, we find the eye of a proportionately larger size than in their representatives at the surface. In such fishes the eyes increase in size with the depth inhabited by them, down to the depth of two hundred fathoms; the large eyes being necessary to collect as many rays of light as possible. Beyond that depth, small-eyed as well as large-eyed fishes occur: the former having their want of vision compensated by tentacular organs of touch, while the latter have no such accessory organs, and evidently only see by the aid of phosphorescence. In the greatest depths occur blind fishes, with rudimentary eyes, and without special organs of touch. Many fishes of the deep sea are provided with more or less numerous, round, shining, mother-of-pearl-coloured bodies embedded in the skin. These so-called phosphorescent or luminous organs are either bodies of an oval or irregularly elliptical shape placed in the vicinity of the eyes, or smaller globular bodies arranged symmetrically in series along the sides of the body and tail." That the function of these bodies is to produce phosphorescent light may be considered certain; and it is probable that both the tentacles and the whole surface of the bodies of these extraordinary fish are also phosphorescent. Not the least remarkable feature about the carnivorous deep-sea fishes is the enormous size of their stomachs, which enable them to swallow creatures nearly as large as themselves; drawing themselves over their prey almost after the manner of a sea-anemone. Although when brought to the surface deep-sea fishes are soft, flabby creatures, with their scales standing out at right angles, and their eyes starting from their sockets, at their own proper level under an enormous pressure, their bodies are doubtless as firm and compact as those of ordinary fish. Deep-sea fish certainly live at a depth of two thousand seven hundred and fifty fathoms.

In regard to geological distribution, it has already been mentioned that the oldest true fishes occur in strata of upper Silurian age, such early fishes being sharks. In the succeeding Devonian and Carboniferous periods the class was abundantly represented, but only by sharks, fringe-finned ganoids, and lung-fishes. In the Permian, Triassic, and Jurassic periods chimæroids, as well as the chondrosteous Teleostomi, made their appearance; but it was not till the Cretaceous epoch that the higher bony fishes, which are the predominant forms in the Tertiary period and at the present day, were developed. There are fully nine thousand known species of living fishes, while considerably more than one thousand fossil forms have been already described.

CHAPTER II.

THE LUNG-FISHES AND CHIMÆROIDS,—Subclasses DIPNOI AND HOLOCEPHALI.

THE two first subclasses of fishes agree with one another, and thereby differ from the remaining two, in the structure of the skull, in which the hyomandibular bone is welded with what is known as the palatopterygoid bar (that is to say, the bones corresponding with the palatines and pterygoids of the higher Vertebrates), which is itself firmly united to the cranium proper, so that there is no separate structure for the suspension of the lower jaw. To this type the name of solid-skulled (technically, autostylic) fishes may be applied; and it may be noted that this type of structure is essentially the same as that on which the skulls of the Amphibians are formed. In the lung-fishes the skeleton is partially ossified, with well-developed membrane-bones, the gill-clefts are but slightly separated, and open into a single cavity protected by an external cover; and the external skeleton consists of true bony tissue. In the existing members of the group the optic nerves (or those proceeding from the brain to the eyes) simply cross one another, without any interlacing of the constituent fibres; the intestine has a spiral valve; the air-bladder is elongated, and performs the functions of a lung; and the nostrils open posteriorly by two apertures into the cavity of the



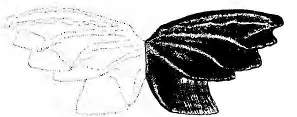
ROOF OF THE SKULL OF THE AUSTRALIAN LUNG-FISH.

A, anterior, and *B*, posterior median plate; *C*, inner, and *D*, outer lateral plate; *na*, nostrils; *orb*, socket of the eyes. (From Teller.)

mouth, after the manner of the higher Vertebrates. The membrane-bones covering the roof of the skull, which are very few in number, cannot be correlated with those of the bony fishes, their mode of arrangement being shown in the accompanying figure. The lung fishes are at the present day represented only by three genera, with but very few species, but they were formerly a very numerous group, which appears to have been on the wane since a very early epoch.

THE EXISTING LUNG-FISHES—Family *LEPIDOSIRENIDÆ*

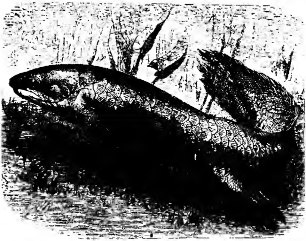
The three existing genera of lung fishes may be taken as the typical representatives of an order including several extinct families, and known as the Sirenoidea. Its essential characters are that the head is covered with membrane-bones; that the main dentition takes the form of large grinding plates, situated on the pterygoid bones in the upper, and on the splenials in the lower jaw; that the body is covered externally with overlapping scales; that the notochord persists throughout life; that the paired fins are of the fringed type; and that none of the fins are armed with spines. The existing forms have but few membrane-bones to the skull; no premaxillæ, maxillæ, marginal teeth, or jugular plates; a fringed tail, furnished with a continuous vertical fin; and cycloid scales.



UPPER PALATAL TEETH OF AN EXTINCT LUNG-FISH (*Ceratodus*). (From Teller.)

Australian Lung Fish For a great number of years there were known from the Triassic strata of various parts of Europe fish-teeth of the remarkable type of the specimen represented in the accompanying figure; and from the fancied resemblance to a deer's antler, presented by these teeth, the name of *Ceratodus* was suggested for the otherwise unknown fishes to which they pertained. Similar teeth were subsequently obtained from Secondary rocks in India and also in South Africa, but it was not until the year 1870 that a fish was discovered in Queensland having teeth of a similar type. Known to the natives, in common with other large fresh-water species, by the name of barramundi, the Australian lung-fish (*C. forsteri*) agrees so closely with the extinct forms that it is usually regarded as generically identical. Its mouth is furnished in front with a pair of chisel-like teeth situated on the vomers, behind which come a pair of palatal teeth of the type of the one shown in the figure, but carrying six complete ridges, and an incomplete seventh;

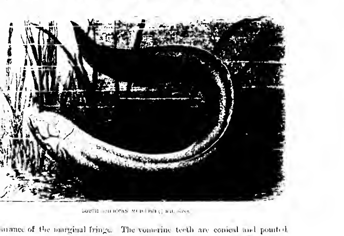
while there are a pair of similar teeth in the lower jaw, carrying only six ridges each. In the living species the teeth of opposite sides are separated by an interval, but in the fossil forms they were in contact, and had fewer ridges. The existing Australian lung-fishes, of which two species have been described, are said to attain a weight of 20 lbs. and a length of upwards of 6 feet. The body is elongated and much compressed, with very large scales; the paddle-shaped limbs have very broad fringes, and the flesh is salmon-coloured. From the occurrence of masses of leaves in its stomach it is evident that the Australian lung-fish crops the vegetation with its great teeth, but it is believed that the most important part of its food consists of the small creatures living on and between the leaves of the various water-plants. The stories of the fish coming out of the water to the land seem quite unfounded, as are those that it lies dormant during part of the year in cocoons. The female lays her rather large eggs loosely and singly among the vegetation, and in the embryo the fore-limbs make their appearance in about a fortnight, but the hinder-pair not before two and a half months. In the course of its development this fish presents marked resemblances to the Amphibians, and also to the lampreys, but it is noteworthy that there is no trace of a sucking mouth, or of external gills. As might have been inferred from the study of allied extinct forms, the large palatal teeth are formed by the fusion of a number of separate small teeth. According to Dr Semon, the Australian lung-fish is confined to the middle portion of the Burnett and Mary Rivers of Queensland. Living among the



AUSTRALIAN LUNG-FISH (½ nat. size).

mud and leaves at the bottom it rises at intervals to the surface to obtain more complete oxygenation of its blood by the inhalation of atmospheric air into its lungs, although its general breathing is carried on by the gills. A grunting noise sometimes uttered by this fish is probably produced by the expulsion of the air from the lungs when it rises to the surface. Although frequently termed the barramundi—a title apparently properly belonging to a totally different fish (*Osteoglossum*)—it appears that the proper native name of the Australian lung-fish is djelleh. The breeding-season is at its height in September and October, but lasts from April till the beginning of November; and the eggs, which are enveloped in a gelatinous coat, and are heavier than water, take some ten days to hatch.

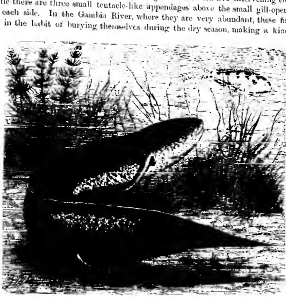
South American Mud-Fish. The mud-fish of the Amazons (*Lepidosiren paradoxa*) is the sole representative of a genus distinguished from the last by the eel-like form of the body on which the continuous vertical fin extends nearly to the neck, and by the reduction of the limbs to mere tapering filaments, owing to the disappearance of the marginal fringe. The vomerine teeth are conical and pointed, and the palatal teeth have strongly marked cusps supported by vertical ridges. There are five gill-arches, with four intervening clefts, but there are no external appendages above the gill-opening. In adult males the upper surface of the hind-limb is beset with tufts of tentacle-like papillæ. This mud-fish grows to a length of about 4 feet, and occurs not only in the Amazon and its tributaries, but likewise in the swamps of the Chaco country forming the tributaries of the upper Paraguay River. The southern form has been regarded as a distinct species, although the differences are so slight as scarcely to merit such a distinction. These fish feed chiefly on the large molluscs known as ampullariæ, which are found collected in



SOUTH AMERICAN MUD-FISH ([illegible] NAT. SIZE).

great masses in the Chako swamps, their shells being easily crushed by the powerful teeth of their devourers.

African Mud Fish. The African mud-fish (*Protopterus annectens*), widely spread over the tropical regions of the continent from which it takes its name, differs from the last in that the filamentous fins retain a small fringe containing rays; as well as in having six gill-arches, with five intervening clefts, while there are three small tentacle-like appendages above the small gill-opening on each side. In the Gambia River, where they are very abundant, these fishes are in the habit of burying themselves during the dry season, making a kind of nest, in which they pass a period of torpidity. Here they may remain for the greater part of the year, only resuming their normal aquatic life with the return of the wet seasons. Professor W. N. Parker, who received some specimens in the torpid condition, writes that about a hundred individuals were dug out and packed up in crates still enclosed in the clods of mud. On arrival in Europe the clods were opened, and the fishes placed in a tank in a hothouse. The statement of the natives that the species grows to the almost incredible length of 6 feet suggests that it must be a very long-lived creature. From the above-mentioned specimens it was found that these mud-fishes grow very rapidly, have great vitality, and, although able to sustain fasts, are exceedingly voracious, devouring all the snails,


AFRICAN MUD-FISH (⅕ NAT. SIZE).

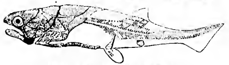
earthworms, and small fish given them, and then killing and eating each other, making it difficult in the extreme to preserve the specimens. They are most active at night, and appear to keep mostly to the shallow water, where they move deliberately about on the bottom, alternately using the peculiar limbs of either side, though their movements do not seem to be guided by any strict regularity. Gray has compared these movements to those of a newt, and several other observers have noticed them. The powerful tail forms a most efficient organ for swimming rapidly through the water. It is well known that this fish comes to the surface to breathe at short intervals, and thus it is evident that the lungs perform an important, if not the chief, part in respiration during the active life of the animal. The air passes out again through the opercular aperture, and the movements of the operculum itself indicate the fact that bronchial as well as pulmonary respiration takes place. Externally, the sexes present no characters whatever distinguishing them apart. As in the American species, external gills are developed in the young. As regards the breeding-habits of these fishes nothing very definite is known. It is stated, however, that the numerous eggs and embryos are carried about in an elongated gelatinous pouch attached to the sides of the back of one of the parents, although the sex in which these receptacles are developed does not appear to have been ascertained. In conclusion, it may be observed that Professor Parker is of opinion that although the lung-fishes present certain resemblances on the one hand to some of the sharks and ganoids, and on the other to the lower Amphibians, yet they appear so distinct from both that he thinks they ought to be removed from the fishes to form a class by themselves.

Extinct Lung-Fishes. In the Palæozoic epoch lung-fishes formed an abundant group, which may be divided into three families. Of these the Carboniferous and Permian *Ctenodontidæ*, as represented by *Ctenodus* and *Sagenodus*, resemble the existing forms in the absence of marginal teeth to the jaw and of jugular plates on the throat, but differ by the numerous membrane-bones of the skull; the caudal fin being of the fringed type, and the scales cycloidal. The type genus, which includes species of 5 feet in length, takes its name from the comb-like structure of the ridged palatal teeth. The second family, *Phaneropleuridæ*, differs from the last in the presence of both marginal teeth and jugular plates; the typical genus *Phaneropleuron*, including small species from the Devonian. In the *Dipteridæ*, as represented by the Devonian *Dipterus* and *Palædaphus*, jugular plates are present, but there are no marginal teeth, and the tail is of the heterocercal type; the skull having numerous membrane-bones. The teeth are very similar to those of the Australian lung-fish, but may be ornamented with small ridges and pustules.

The Berry-Bone Fishes.—Order Arthrodira.

The extraordinary Palæozoic group typically represented by the berry-bone fish (*Coccosteus*) of the Scottish Devonian differs from the true lung-fishes in that in place of scales the fore-part of the body is protected by large bony plates, of which one pair is articulated by a hinge to the hinder-part of the skull, which is likewise invested with bones bearing a similar pustular, or berry-like sculpture.

The fore-limbs were either rudimental or wanting; but a pair of pelvic fins were developed. Most or all of the forms may be included in the single family *Coccosteidæ*; and among these the typical genus is distinguished by the absence of any pectoral fin, while in the allied *Brachydirus* this appendage is represented by a hollow spine. In both these the sockets of the eyes form notches on the sides of the skull; and the same is the case with the gigantic *Dinichthys* of the North American Devonian. In another group, however, as represented by *Homosteus*, the eye-sockets were completely enclosed in the membrane-bones with which the head is covered.



PARTIAL RESTORATION OF THE BERRY-BONE FISH.
(From A. S. Woodward, *Cat. Foss. Fishes, Brit. Mus.*)

THE CHIMÆROIDS,—Subclass Holocephali.

Represented by three existing marine genera, of which one has three, the second one, and the third two species, and a number of extinct types, the chimæroids form a second subclass, agreeing with the lung-fishes in their solid (autostylic) skulls, but differing by the total absence of membrane-bones, and their superficial external resemblance to sharks. The skeleton is cartilaginous, with the notochord either persistent, or constricted and surrounded by cartilaginous rings, which are sometimes partly calcified; and in the adult the skin is frequently quite naked, although in the young it may bear on the back a series of structures similar in composition to teeth, some extinct forms having plates of the same nature. In the existing members of the group the optic nerves simply cross one another, and the intestine has a spiral valve; while further resemblances to the sharks are shown by the presence of claspers in the males, and also by the large size and small number of the single eggs. The four gill-clefts open externally by a single aperture on each side, protected by a fold of skin containing a cartilaginous operculum. The mouth is situated at the extremity of the muzzle, and the teeth on the palate and lower jaw are molar-like, while there is also a small pair of cutting vomerine teeth in the front of the upper jaw; the whole dentition thus closely corresponding to that of the lung-fishes, although there are two pairs of upper palatal teeth, which present certain hardened areas known as *tritors*. The pectoral fins are shortened, without the segmented axis of the lung-fishes; and the first dorsal fin may have a movable spine articulated to the spinous processes of the vertebræ. The sides of the body show a lateral line; but there is no air-bladder, and the nostrils do not open behind into the cavity of the mouth. It has been suggested that the chimæroids indicate a degenerate group nearly allied to the lung-fishes, which have lost the membrane-bones of the latter, and acquired a superficial resemblance to sharks.

The ugly fish, to which the name chimæra has been applied (*Chimæra monstrosa*), together with two other existing species, typically represents the family *Chimæridæ*, which alone has survived to the present day. The family is characterised by the presence of a spine to the first dorsal fin, and also of a prehensile spine-like structure on the heads of the males; there are no superficial plates on the skull, and only a single pair of lower teeth. The family, which contains a number of extinct genera, mainly distinguished from one another by the characters of the triturating areas on the teeth, dates from the Lias; the typical genus being, however, unknown before the latter part of the Tertiary period. The living chimæras do not probably exceed 5 feet in length, and have the soft muzzle devoid of an appendage. The dorsal fins occupy the greater part of the back; and the longitudinal axis of the long filamentous tail is nearly continuous with that of the back, its extremity being provided above and below with a long, low fin of the diphycercal type. The common species represented in the annexed coloured Plate ranges from Europe and Japan to South Africa; while a second occurs on the Pacific Coast of North America, and a third off Portugal. The southern chimæra (*Callorhynchus antarcticus*), from the southern temperate seas, differs from the preceding genus by the presence of a cartilaginous prominence, ending in a flap of skin, on the muzzle, and likewise by the upward direction of the extremity of the tail, which has no fin on its upper surface. A fossil representative of this genus occurs in the Cretaceous rocks of New Zealand. The third genus *Harriotta*, distinguished by the extreme elongation of the snout, is represented by one species from the Atlantic, and a second from the Pacific. As well-known extinct types of the family we may refer to the Cretaceous and Tertiary genera *Edaphodon* and *Elasmodus*; the former including fishes of gigantic dimensions. The members of the extinct family *Myriacanthidæ*, of the Jurassic rocks, differ by having a few bony plates on the head, and three lower teeth; while the *Squalorajidæ*, as represented by *Squaloraja* of the Lias, were somewhat ray-like forms, with a depressed trunk and elongated muzzle, and no spines to the dorsal fins. The subclass appears also to be represented in Palæozoic times, the Devonian *Ptyctodus* indicating a family which cannot at present be fully defined.

CHAPTER III.

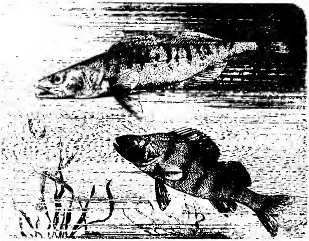
THE BONY FISHES AND GANOIDS,—Subclass TELEOSTOMI.

FORMERLY the typical bony fishes of the present day were regarded as indicating a primary group (Teleostei) of equal rank with a second one known as the Ganoidei; the latter containing the American bony pike, and the African bichir, together with a host of extinct genera possessing a similar armour of hard ganoid scales. A fuller study of these and other allied fossil forms has, however, shown the existence of such a complete transition from these so-called ganoids to the typical bony fishes that it has become necessary to include the whole of them in a single subclass, under the title heading this chapter. Although there is still some degree of uncertainty as to the best mode of arranging certain groups of the bony fishes, the following scheme may be temporarily adopted:—

1. Order ACTINOPTERYGII—Fan-Finned Group.
    - (1) Suborder PHYSOCLISTI { ACANTHOPTERYGII—Spine-Finned Fishes.
    - (2) „ LOPHOBRANCHII—Tuft-Gilled Fishes.
    - (3) „ PLECTOGNATHI—Comb-Gilled Fishes.
    - (4) „ ANACANTHINI—Soft-Finned Fishes.
    - (5) „ PHYSOSTOMI—Tube-Bladdered Fishes.
    - (6) „ ISOSPONDYLI—*Leptolepis.*
    - (7) „ ÆTHEOSPONDYLI—Bony Pike.
    - (8) „ PROTOSPONDYLI—Amioids.
    - (9) „ CHONDROSTEI—Sturgeons.
2. Order CROSSOPTERYGII—Fringe-Finned Group.

In this wide sense the subclass differs broadly from the two preceding ones in the structure of the skull, which is formed on what may be termed the hinged type (*hyostylic*): that is to say, the palato-pterygoid bar remains separated from the cranium proper, to the hinder-part of which it is movably articulated by the intervention of the hyomandibular. The internal skeleton is more or less ossified, with the development of membrane-bones on the jaws; the gill-clefts are but slightly separated from one another, and are fully protected by an operculum; the membrane-bones of the pectoral girdle (that is to say, the scapula, claviculars, etc.) are connected with the hinder-part of the skull; and the external skeleton takes the form either of plates of bone or of calcified overlapping scales. In existing forms the eggs are small, numerous, and generally massed together; the two optic [illegible] simply cross one another, or may give off mutually interlacing [illegible] adder—with or without a duct—is very generally present; and the intestine may sometimes be furnished with a spiral valve.

Fan-Finned Group. This group (Actinopterygii) includes all the bony fishes of the present day, as well as the sturgeons, and is characterised by the fan-like structure of the paired fins, in which the proper internal skeleton is abbreviated to make way for the greatly developed dermal fin-rays; the caudal fin being of very variable structure. In the branchiostegal membrane, occupying the space between the two branches of the lower jaw, there is always a paired series of transversely elongated rays. The first eight suborders of this order, given in the table on p. 333, form one great division characterised by the number of dermal rays in the dorsal and anal fins being equal to that of the supporting



PIKE-PERCH AND COMMON PERCH (⅙ nat. size).

bony elements, and by the tail being never heterocercal[1] but usually either of the abbreviate-heterocercal or homocercal type, although occasionally diphycercal.

Spine-Finned Fishes. In the classification proposed by Professor Cope the first four suborders of the fan-finned group given in the foregoing table are regarded as a single group, under the title of Physoclysti, and in common with the tube-bladdered fishes, have the fibres of the optic nerves interlacing, the intestine without a spiral valve, and the skeleton fully ossified. From the Physostomi, the

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[1] In the heterocercal type the upper lobe of the tail is the longer, and the vertebral column is continued up into it; in the abbreviate-heterocercal the tail is symmetrical, and the vertebral co[illegible] st fold up into its upper half; in the homocercal type the tail is also symmetrical, but the vert[illegible] ts less where the latter ones are aborted into a mass; in the diphycercal form the vertebrae are [illegible] along the middle line of the symmetrical tail-fin.

Physoclystous group are distinguished by the general absence of a duct to the air-bladder (when present), by the parietal bones of the roof of the skull being always separated from one another by the intervention of the supraoccipital, and by the pelvic fins being in most cases either thoracic or jugular[1] in position. Regarding, however, the spine-finned fishes as constituting a separate suborder, they are distinguished in addition to the foregoing characters, by some of the anterior rays of the dorsal, anal, and pelvic fins usually taking the form of strong unjointed, bony spines. It must, however, be acknowledged that this character is one of but little importance, some of the hair-tails (*Trichiuridæ*) scarcely possessing what can be denominated true spines, while these are also wanting in the family (*Scombresocidæ*) to which the flying-fishes belong. In all cases the gills are comb-like, the pectoral arch is suspended from the skull, and interclavicles are wanting.

THE PERCH TRIBE.—Family *PERCIDÆ*.

The first representatives of the spine-finned fishes are the perches, which, with several allied families, belong to a sectional group (*Perciformes*) of the suborder, characterised by the lower pharyngeal bones being generally separate, and the scales usually of the ctenoid type. The preopercular bone of the gill-cover has no bony stay connecting it with the eye; the spinous portion of the dorsal fin is well developed, none of the additional rib-like bones known as epipleura are attached to the bodies of the vertebræ; the pelvic fins are thoracic in position, and have usually five (rarely four) branched rays; and the supporting bones (pterygials) of the pectoral fins are longer than broad and of a more or less distinctly hour-glass form. The perch family, as restricted by Mr. Boulenger, is distinguished by the following characters. In the skeleton the anterior vertebræ have no transverse processes, but in the dorsal part of the series all or most of the ribs are attached to such processes. There are two nostrils on each side; the gill membranes are free from the isthmus, or space between the two branches of the lower jaw and gill-openings; there are four pairs of gills, with a slit behind the fourth; the gill-rays, or branchiostegals, vary from six to eight on each side; more or less fully-developed false gills are generally present; the soft portion of the dorsal fin is not very much more developed than the anal; and the latter has either one or two spines. In common with the two following families, the perches are further characterised by the general presence of a lateral line, continuous from the head to the tail, the usual absence of scales from the median fins, the simple conical teeth, and the absence of barbels round the mouth. In form the body is more or less elongate, compressed, and cylindrical, although rarely it may be slightly compressed. As now restricted, the family includes a dozen genera inhabiting the fresh waters of North America, Europe, and Western Asia; but the members of the genera *Lucioperca* and *Percarina* enter salt water. All are carnivorous.

True Perches.

The common perch (*Perca fluviatilis*), which is a fish of wide distribution, and one too familiar to require detailed description, is the type of a small genus, agreeing with eight others in the following characteristics

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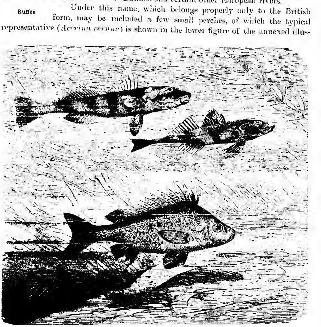
[1] They are said to be thoracic when in the same vertical line as the pectoral fins, and jugular when in advance of them.

In the head the mucous or slime-canals are but moderately or slightly developed on the top and at the sides; and the spinous and soft portions of the dorsal fin are separate. In common with six other genera, the body is more or less compressed; the perches and pike-perches being specially distinguished by having usually seven (rarely eight) gill-rays; by the premaxillæ, or anterior upper jawbones, being capable of protrusion; and by the serration of the preopercular bone of the gill-cover. As a genus the true perches are distinguished from the pike-perches by the small and uniform size of the marginal teeth, and the close approximation of the pelvic fins. There are teeth on the palatine and vomerine bones, but none on the tongue, and there are thirteen or fourteen spines in the first dorsal fin, and two in the anal. The scales are small, the upper surface of the head is naked, the preorbital as well as the preopercular bone is serrated, and there are seven branchiostegal rays, and more than twenty-four vertebræ. As in most of the members of the family, the mouth is capable of a certain degree of protrusion. The common perch, which seldom exceeds 5 lbs. in weight, is distributed over the rivers of Europe (except Spain) and Northern Asia as far east as Lake Baikal; two others being known, namely, *P. flavescens* from the Eastern United States and *P. schrenki* from Turkestan. Generally preferring still waters, and occasionally descending into estuaries, the perch is one of the most voracious of fishes, feeding indiscriminately upon worms, insects, and small fishes. The spawning-season in England is at the end of April or May, when the female deposits her eggs in net-shaped or elongated bands on the leaves of aquatic plants. The eggs are very numerous, upwards of two hundred and eighty thousand having been taken from a fish of ½ lb. in weight. Fossil remains of the genus occur in the Miocene rocks of Œningen, in Baden, and those of the extinct *Paraperca* in the upper Eocene of Provence.

Pike Perches. The pike-perches, of which the common European representative (*Lucioperca sandra*) is shown in the upper figure of the illustration on p. 334, are inhabitants of many of the lakes and rivers of Europe, Western Asia, and Eastern North America, and take their name from their somewhat elongated and pike-like form. From the true perches they differ by the presence of more or less enlarged tusks in the marginal series of teeth, and by the wider interval between the pelvic fins. The two dorsal fins are rather low, the first having from twelve to fourteen spines; and the scales are small. The common species, which is confined to Eastern Europe, where it is much esteemed as a food-fish, grows to a length of 3 or 4 feet, and attains a weight of from 25 to 30 lbs. Its extreme voracity and destructiveness to other fish render it an undesirable inhabitant of preserved waters.

Danubian Perches. The two small and rather elongated perches represented in the upper part of the illustration on p. 337, the larger of which is known as *Aspro zingel* and the smaller as *A. vulgaris*, may be taken as representatives of a subgroup distinguished from the foregoing forms and their allies by the body being cylindrical or somewhat depressed; while from two allied genera they are distinguished by the maxilla or main upper jawbone being covered by the preorbital bone, and by the premaxilla being free only at the side. The body is elongate and nearly cylindrical in form; and the mouth situated on the lower surface of the thick and somewhat projecting muzzle. All the teeth of the jaws are of small and uniform size, and teeth are present on the vomer and palatine bones. The anal fin has but a single spine; although the margin of the propercular bone is serrated, that of the preorbital is smooth, and the scales are small. These fishes inhabit the Danube and certain other European rivers.

Ruffes Under this name, which belongs properly only to the British form, may be included a few small perches, of which the typical representative (*Acerina cernua*) is shown in the lower figure of the annexed illustration. From the other members of the family this and the allied genus *Percarina* differ by the large size of the slime cavities on the sides and top of the head; the ruffes being specially distinguished by the dorsal fin being undivided, and also by the maxilla being covered by the preorbital bone. The fishes of this genus have the body somewhat low, and the scales somewhat small; the continuous single dorsal fin carrying from thirteen to twenty-nine spines; and there being two spines in the anal fin. There are no tusks among the small teeth of the jaws, and the tongue and palatine bones are devoid of teeth, although these are present on the vomer. The genus is confined to the cooler portions of the Northern Hemisphere,



LARGER AND SMALLER DANUBIAN PERCHES, AND RUFFE (¼ nat. size).

the common species ranging from Britain through Central Europe to Siberia. The "pope," as the ruffe is frequently called in England, is common in most of the rivers and canals of that country, generally preferring slow, shaded streams, with a gravelly bottom, and closely resembling the perch in its mode of life.

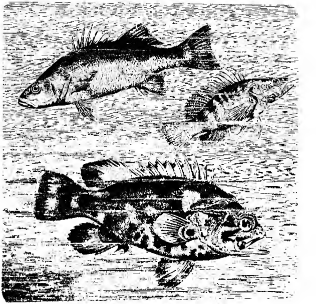
Family Centrarchidæ. Here may be mentioned a small family, with ten genera of perch-like fishes, distinguished from the *Percidæ* and the following family by the mode of attachment of the ribs, which, with the exception of the last, or last two or four, are inserted on the bodies of the vertebræ behind the transverse process, instead of the process itself; all the vertebræ in front of the tail, save the first two or three, having such processes. Externally these fishes differ from the perches in the presence of at least three spines in the anal fin. The family is typified by the North American genus *Centrachus*, of which there is but a single species. All are carnivorous fresh-water fishes, sometimes entering estuaries, and many are in the habit of building nests for the protection of their young.

BASS AND SEA-PERCHES,—Family *SERRANIDÆ*.

Although usually included in the *Percidæ*, with which they agree in the structure and relations of the vertebræ and ribs, the sea-perches and their allies are regarded by Mr. Boulenger as representing a family by themselves, on account of the circumstance that the second suborbital bone develops an internal plate for the support of the eye. The number of spines in the anal fin is variable; and in one genus (*Centrogenys*) the lower pharyngeal bones are united. The family is a very extensive one, and may be divided into several subfamily groups.

South American Perch and Bass. Together with the sea-perches, the bass represent a subfamily (*Serranina*) presenting the following characteristics. The upper jawbone, or maxilla, is exposed, its upper border not being entirely concealed by the overlapping preorbital; the scales are not shed; there is no scaly process at the bases of the pelvic fins; the anal fin has three spines; the gill-membrane is free behind; and the false gills are well developed. In distribution the subfamily is cosmopolitan, and while most of the forms are marine, a few inhabit fresh water. Among the latter may be mentioned the South American perch (*Percichthys*), of Chili, Western Argentina, and Patagonia, which, in common with five other genera, has a divided dorsal fin. From an ordinary perch these fish may be distinguished by the scaly upper surface of the head, and the presence of nine or ten spines in the first dorsal, and three in the anal fin. To this section of the subfamily also belong the bass (*Morone*), which are partly marine and partly fresh-water fishes, easily distinguished from the true perch by having only nine spines in the dorsal fin, while there are usually three in the anal. There are also teeth on the tongue; and while the preopercular bone is serrated, with denticulations on its lower border, the front border of the preorbital bone is entire. The scales are rather small, and extend all over the head. Of the three European and Atlantic species, which are almost entirely marine, the best known is the common bass (*M. labrax*), represented in the upper figure of the illustration on p. 359, and characterised by its extreme voracity and fierceness. Elsewhere, the genus is represented by fresh-water species from the rivers of the United

States and Canada. Fossil species occur in the middle Eocene of Italy. Generally not exceeding a foot or 18 inches in length, the common species may grow to 3 feet; but its flesh is then much less delicate than that of ordinary specimens. Bass frequent the coast in shoals, spawning in summer generally near the mouths of rivers, up which they not unfrequently ascend for considerable distances.



COMMON BASS, SEA-PERCH, AND STONE BASS (¼ nat. size).

Sea-Perch. In the other genera of the subfamily the dorsal fin is undivided, although it may be deeply notched; the number of its spines being generally nine or eleven, although there may be either eight, ten, or twelve. Under the common title of sea-perches may be included the members of several allied genera, such as *Centropristes* and *Anthias*, although the name is often restricted to those of the typical genus *Serranus*, one of which (*S. scriba*) is represented in the middle figure of the above illustration. In the sea-perches the body is oblong or compressed, and covered with small ctenoid or cycloid scales; there are large tusks among the villiform teeth of the jaws; and teeth are also present on the palatines and vomers, although absent from the tongue. The preopercular bone is serrated behind and at the angle, but not inferiorly; and the tail-fin may be either rounded, squared, or emarginate. The sea-perches of the genus *Serranus*, of which there are an enormous number of species, range through the seas of all the tropical and temperate regions, occasionally ascending tidal rivers for short distances in pursuit of prey, but being otherwise strictly marine. Many of the species vary considerably, both in colour and in the form of their fins, with age, so that specific distinctions are difficult to establish. Extinct species of this genus, as well as others belonging to *Lates*, occur in the middle Eocene deposits of Italy.

Stone-Bass. The fish represented in the lower figure of the illustration on p. 339, and commonly known as the stone-bass (*Polyprion cernuum*), is one of two species constituting a genus distinguished from the last by the absence of large tusks in the jaws, and the presence of teeth on the tongue; the single dorsal fin having eleven or twelve spines, and the anal three. The preopercular bone is denticulated, and there is a strongly marked rough longitudinal ridge on the opercular. The common species is abundant on the European coasts, while the second is from the seas of Juan Fernandez. Both attain a very large size, ranging in weight to 80 lbs. or more, their flesh being of excellent quality. The European stone-bass frequents the neighbourhood of floating wood, probably for the purpose of feeding on the creatures to be met with around such objects.

Oriental and African Perches. The two species of the genus *Lates*, one of which (*L. niloticus*) inhabits the mouth of the Nile, while the second (*L. calcarifer*) ranges from the shores of Baluchistan through the Indo-Malayan seas to China and Australia, may be taken as representatives of another subfamily (*Centropominæ*), with three genera; this subfamily differing from the last by the extension of the lateral line on to the tail-fin, the presence of a scaly process at the bases of the pelvic fins, and the small size or absence of the false gills. Having no teeth on the tongue, and a divided dorsal fin, these fish may be distinguished externally from the true perches by the presence of seven or eight dorsal, and three anal spines. Both the preopercular and preorbital bones are serrated, and the latter denticulated at the angle; the finely pectinated scales being of moderate size. The Indian perch, which may grow to a length of 5 feet, is the only Oriental member of the family which commonly ascends rivers to any distance. When taken in the larger rivers its flesh is excellent for the table, great quantities being sold in the Calcutta market, where it is commonly known by the name of cock-up. The allied genus *Psammoperca* is represented by two species, one ranging from Australia to China, while the other is exclusively Australian. There are many other generic representatives of this extensive family, which are far too numerous to mention, no less than twenty-seven occurring within the limits of British India. Among these the Indian genus *Pristipoma*, which is referred by some writers to a separate family, is represented by extinct species in the middle Eocene of Italy; and it may be mentioned here that the earliest known forms of the family are the extinct genera *Podocys* and *Acanus* from the lower Eocene of Switzerland.

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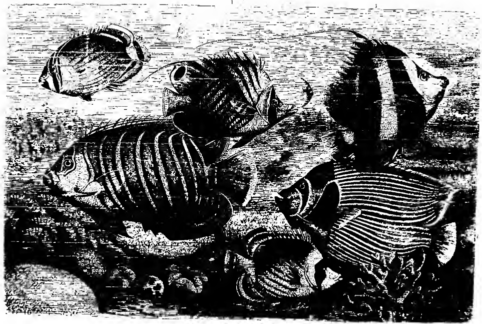

GROUP OF SCALY-FINNED FISHES.

1, *Chætodon setifer*; 2, *C. [illegible]*; 3, *C. trifasciatus*; 4, *Heniochus macrolepidotus*; 5, *Holacanthus Lamarckii*; 6, *H. imperator*.

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a tube-like form, on account of the habits of one of its two Indian species (*Chelmon rostratus*). Of this fish, which has four dark bands on the head and body, and an eye-spot on the soft dorsal fin, J. A. Schlosser wrote many years ago that it frequented the shores and sides of the sea and rivers in search of food, and that when it detected an insect perched on a plant it swam to within a distance of from four to six feet, and then with surprising dexterity ejected out of its tubular mouth a single drop of water, which never failed to strike the object aimed at into the water, where it was immediately seized by the fish. Some of these fish kept in tubs of water were seen to exercise their shooting powers even under these somewhat unfavourable circumstances. Somewhat later a Mr. Mitchell observed the same action in some of these fish kept in a pond near Batavia about the year 1828. Curiously enough, in spite of these circumstantial statements, this capacity for ejecting water was transferred to a short-snouted member of the present family, which received its name of *Toxotes* from this presumed power. Bleeker states, however, that when in Batavia he never witnessed this act, which is one the mouths of these fishes would appear quite incapable of performing.

Heniochus.

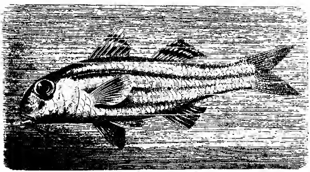
The fish (*Heniochus macrolepidotus*) numbered 4 in the illustration on p. 342, is a common Indo-Pacific member of a genus differing from *Chætodon* by the more or less marked elongation of the fourth spine of the dorsal fin, which in the figured species assumes the form of a whip-lash. Broad dark bands across the body are very characteristic of the genus; and in the young the head is armed with numerous horn-like processes, which are permanently retained in a species named *H. varius*.

Holacanthus.

The two large fishes shown in the illustration, swimming towards the left, belong to a genus distinguished from all the foregoing by the presence of a large spine on the hinder-edge of the preopercular bone; the dorsal fin having from twelve to fifteen spines. The genus includes some forty species, with the same range as the typical representative of the family. The splendidly-coloured emperor-fish (*H. imperator*), shown on the right side of the illustration, ranges from the east coast of Africa to the Indian and Malayan seas, and has the ground-colour of the body a deep blue, upon which are some thirty longitudinal golden yellow stripes. The eye stripe and a patch above the pectoral fin are black edged with yellow; and the tail-fin is uniformly yellow. This species, which attains a length of 15 inches, is extensively used in India for food. Beautiful as it is, it is exceeded by the Indo-Malayan zebra-fish (*H. diacanthus*). In this species the general colour is yellowish, with from eight to twelve vertical brown-edged blue bands; the caudal fin is yellow, and the anal marked with bluish lines running parallel to its margin. The genus *Scatophagus* may be given as an example of a group in which the spinous portion of the dorsal fin is devoid of scales and separated by a deep notch from the soft part, so that there are practically two dorsals. The above-mentioned *Toxotes*, on the other hand, constitutes a group by itself, in which there are teeth on the palatines and vomers, and the body is oblong and much less deep than in the typical forms, with the undivided and five-spined dorsal fin situated in its hinder-half. It is represented by three species, ranging from the Red Sea to the seas and estuaries of India, Malayana, and Polynesia.

THE RED MULLETS,—Family *MULLIDÆ.*

Two long erectile barbels dependent from the lower jaw serve at once to distinguish the red mullets from all the preceding families, with which they agree in the characters already mentioned. In these well-known fishes the body is rather low and somewhat compressed, with large thin scales, of which the edges may be very finely serrated. The lateral line is continuous, and the moderate-sized eyes are situated on the sides of the head. The terminal mouth has a rather short lateral cleft, and the teeth are very feeble. There are two short dorsal fins, placed at a considerable distance from one another, the spines of the first being weak, and the second being placed above the anal, which it resembles in form. The ventrals have one spine and five rays, and the pectorals are short. In place of the seven branchiostegal rays of the perches, the red mullets have but four. Represented by something like forty species, the red mullets, which range over the seas of Europe and the tropics, are typically represented by the genus *Mullus*, of which there appears to be but a single European species (*Mullus barbatus*). The tropical forms have, however, been split up into several genera, such as *Mulloides*, and *Upeneus*, mainly distinguished from one another by the characters of their teeth. Although these mullets are essentially marine, young individuals, and more rarely adults, are not unfrequently taken in rivers. They are all highly esteemed for the table, and it is but seldom that they attain a weight of even 2 or 3 lbs. The ordinary European red mullet, which does not usually exceed 6 inches in length, is coloured carmine-red on the upper-parts, the under-parts being silvery white. On the other hand, the striped mullet, which, although designated a distinct species under the name of *M. surmuletus*, is regarded by Dr Günther as probably the female of the former, has three or four yellow longitudinal stripes on the sides; and is also stated to differ slightly in the number of the fin-rays. This kind is common on the Cornish coast, whereas the plain-coloured form is but



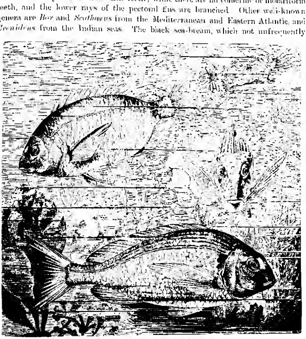
STRIPED RED MULLET (½ nat. size).

seldom met with in the British seas, although abundant in the **Mediterranean.** Mullets live chiefly on small crustaceans, frequenting coasts where **the bottom is** more or less muddy. Occasionally they visit the British coasts in **vast shoals,** upwards of five thousand having been taken during a single night, in **August** 1819, in Weymouth Bay; while in May 1851 no less than ten **thousand were** captured at Yarmouth in the course of a week. Whereas by the ancient **Romans** these fish were known by the name of *mullus*, the Greeks termed them *trigle*. "**A** singular circumstance," writes Badham, "about this latter synonym is, that it **not** only obtains in modern Greece (where, indeed, if anywhere, we might **expect to** find it) but has also entirely supplanted the old Latin word in Italy; so **that no** one now ever hears *Mugli! mugli!* hawked about the streets of Rome or **Naples**; but the constant cry is '*Trigle vive! trigle!*' The inordinate love for these same *trigle*, in the city and times of the Cæsars, would surpass belief; not only cash, but time too, was profusely lavished upon this one object; quite betimes, and long before office-hours, the mullet-millionaire was at the pond ere the stars were extinguished, feeding or caressing his fish. It took time, skill, and patience to teach creatures so obtuse to heed the voice that called, or the hand that fondled and fed them; but to warm such cold-blooded animals as these into a reciprocity of regard, was a work of yet greater difficulty." After much trouble and pains, the inhabitants of the pond would, however, at length learn to know and acknowledge their master; at his whistle flock emulously together, at his sight leap joyously into the air; and as he plunged his arm into the agitated basin, each individual of the serried shoal strove who should first present fins, and rub scales against the well-known fingers!"

THE SEA-BREAMS.—Family *SPARIDÆ*

The sixth family of the present section is especially characterised by the peculiarity of the dentition, the palate being generally devoid of teeth, while either cutting or conical incisor-like teeth are developed in the front of the jaws, or crushing molars on their sides; in some cases both these types being coexistent. In the sea-breams, as these fish are commonly called, the oblong body is markedly compressed, and the investing scales are either but very slightly serrated, or smooth. The terminal mouth has a distinct lateral cleft, and the eyes, which are of medium size, are likewise lateral. The single dorsal fin is composed in about equal moieties of a spinous and a soft portion; the anal is three-spined; as a rule the lower rays of the pectorals are branched; and the pelvics, which are ventral in position, are furnished with one spine and five rays. The number of branchiostegal rays varies from five to seven. Sea-breams are coast-fishes, distributed over all temperate and tropical seas, and sometimes entering brackish and even fresh waters; they include a large number of genera, and are of sombre coloration and medium size; the flesh of the majority being used for food. In a fossil state the family is first known by the extinct *Pagellus* from the Chalk of the Lebanon; while they are numerous in Tertiary formations, where both the living and extinct genera are met with, the existing *Sargus* dating from the Miocene of the Continent.

Cantharus. The black sea-bream (*Cantharus lineatus*), of the British seas, may be cited as a well known example of the typical genus of the first subfamily, in which the extremities of the jaws are furnished with broad, cutting, and occasionally lobate incisor-like teeth; while there are no vomerine or molariform teeth, and the lower rays of the pectoral fins are branched. Other well-known genera are *Box* and *Scatharus* from the Mediterranean and Eastern Atlantic, and *Crenidens* from the Indian seas. The black sea-bream, which not unfrequently grows to a length of 15 inches, is common on the British coasts, where it will take both vegetable and animal baits.



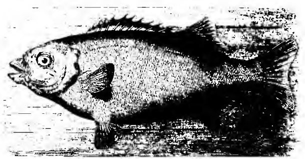
SARGO AND GILT-HEAD (⅓ nat. size)

Haplodactylus. The second group is represented by *Haplodactylus*, from the temperate South Pacific, in which both jaws are furnished with flat and generally tricuspid teeth; vomerine teeth being present, but molars wanting, while the lower pectoral rays are simple. These fish are vegetable-feeders.

Sargus. Better known than the last is the third group, containing only the single genus *Sargus*, with some twenty species from the Mediterranean, Atlantic, and Indian seas, among which the common sargo (*S. annularis*), represented in the upper figures of our illustration on p. 347, is a familiar fish on the Continent. The essential features of the group are the single series of cutting-teeth in the front of the jaws, the presence of several rows of molars on the sides of the same, the toothless palate, and the simple lower pectoral rays. The figured species is a uniformly coloured fish; but in the larger "sheep's-head" (*S. ovis*), from the Atlantic coasts of the United States, which attains a weight of 15 lbs. and is highly esteemed for the table, the body and tail are marked by a number of broad vertical bands. The strong molars of these fish indicate that their food consists of hard-shelled molluscs, crustaceans, or sea-urchins. Known there as *dentice*, these fishes form part of the bill of fare on the tables of hotels in Southern Italy.

Gilt Heads.

As our example of the fourth subfamily, which contains several genera, among which *Pagrus* is the typical one, we select the gilt-heads (*Chrysophrys*), so-called on account of the golden spots between the eyes of the Mediterranean *C. aurata*, a species which occasionally wanders to the British coasts, and is shown in the lower figure of our illustration. The group is characterised by the presence of conical teeth in the front of the jaws, and of molars on their sides, the palate being toothless; while the genus under consideration is distinguished by having scales on the cheeks, and at least three rows of upper molars. The Mediterranean gilt-head, which ranges southward as far as the Cape, is a handsome fish, with a short and elevated head, the body deepest at the commencement of the dorsal fin, the iris yellow, a semilunar golden spot between the eyes, and a violet patch on the gill-cover. The back is silvery grey with a tinge of blue, and the under surface steely, with longitudinal golden bands on the sides. In length it seldom exceeds a foot. Fully adult examples show a perfect pavement of teeth on the jaws; and with these the fish crunches up mussels and other shell-fish with such vigour that the noise thus made sometimes reveals its presence to fishermen. In order to obtain food, it is stated to stir up the sand of the sea-bottom with its tail. The gilt-eye was one of the fishes kept and fattened by the

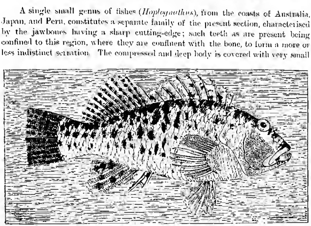


AUSTRALIAN KNIFE-JAWED FISH (⅓ nat. size).

Romans in their vivaria, where it is said to have become extremely flat. Several species of the genus inhabit the seas and estuaries of India, one of which (*C. berda*) occasionally grows to 30 inches in length, and is much esteemed as food in Madras, where it is known as black-rock cod. Fossil teeth of a gilt-head occur in the Red Crag of Suffolk, and the Miocene strata of Malta and the Canaries.

THE KNIFE-JAWED FISHES.—Family *HOPLOGNATHIDÆ*.

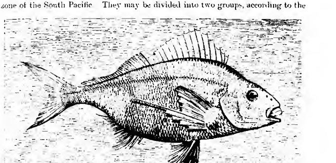
A single small genus of fishes (*Hoplognathus*), from the coasts of Australia, Japan, and Peru, constitutes a separate family of the present section, characterised by the jawbones having a sharp cutting-edge; such teeth as are present being confined to this region, where they are confluent with the bone, to form a more or less indistinct serration. The compressed and deep body is covered with very small ctenoid scales; while the sides have a continuous lateral line. The dorsal fin has its spinous portion rather longer than the soft, with the spines very strong; the anal, which has three spines, is similar to the soft dorsal; and the thoracic pelvics are furnished with a single spine and five rays. The species figured on the opposite page is the Australian one (*H. conwayi*). Nothing seems to have been ascertained with regard to the life-history of any member of the family.



SPOTTED FIRM-FIN (½ nat. size).

THE THICK-RAYED FISHES,—Family *CIRRHITIDÆ*.

This small family, which, for want of a better English name, we designate as above, comprises several genera from the Indo-Pacific and Australasian seas, some members of which are of the first importance as food-fishes in the British colonies. Closely allied to the next family, they differ therefrom (and thereby resemble the preceding groups) in the absence of a bony connection between the preopercular bone and the infraorbital ring of the skull; while they are specially distinguished by the thickened and undivided lower rays of the pectoral fin, which in some cases are elongated so as to aid in the movements, while in others they may perhaps serve as additional organs of touch. In form, the body is oblong and compressed, with its investing scales of the cycloidal type; the mouth is terminal, with a lateral cleft; and the eyes are situated on the sides of the head. As a rule, the branchiostegal rays are six in number, although they may be reduced to five or three. The teeth are villiform or pointed, and in some cases there are tusks among the smaller ones. In the single dorsal fin the spinous and soft portions are of nearly equal extent; the anal fin, which is generally smaller than the soft dorsal, carries three spines; and the pelvics, which, although thoracic in position, are situated at a considerable distance from the root of the pectorals, have one spine and five rays. These fishes are inhabitants of all tropical seas and the temperate zone of the South Pacific. They may be divided into two groups, according to the presence or absence of teeth on the vomers; the first group including the small prettily coloured fishes known as *Cirrhites*, *Chorinemus*, etc., of which the former are characteristic of the Indian and Pacific oceans, while the latter is confined to the Australasian seas.



AUSTRALIAN LONG-FIN (½ nat. size).

Cirrhitichthys. Of the group with teeth on the vomers we illustrate on p. 349 a species (*Cirrhitichthys marmoratus*) of a genus differing from the typical one by the presence of teeth on the palatine bones, and by the spiny opercular bone; the preopercular being serrated in both. These fish have six branchiostegal rays, tusks in the jaws, and ten spines in the dorsal fin. Five to seven of the lower pectoral rays are unbranched, the scales are of moderate size, and there is no air-bladder. The spotted firm-fin, which ranges from the Red Sea, through the Indian and Malayan seas to the Sandwich Islands, is one of those in which there is no elongation of a ray of the pectoral fins; while it is specially characterised by the spotted coloration, the body and median fins showing brown spots and a few of darker spots occupying the base of the dorsal.

Chilodactylus

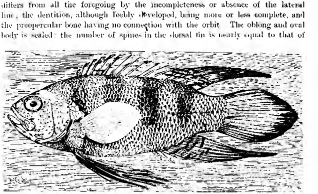
In the group with toothless vomers, one of the most notable genera is that of the long fins (*Chilodactylus*), so named on account of the elongation of one of the rays of the pectoral fins, which projects to a greater or less degree beyond the rest. A considerable number of species have been described, most of which are inhabitants of the temperate region of the South Pacific, although some are found round the coasts of Japan and China. The species here figured (*C. macropterus*) is an Australian one; and both in Australia and at the Cape these fishes form a valuable food-supply, since they attain a weight of from 5 to 25 lbs., and are easily captured. An allied genus (*Latris*), distinguished by the absence of any elongation of the pectoral rays and the deeply notched dorsal, is well known in Tasmania and New Zealand in the person of the trumpeter-fish (*L. hecateia*), which claims the first place among the fish-products of those colonies, ranging in weight from 30 to 60 lbs., and being at the same time most excellently flavoured.

THE SCORPÆNOIDS. Family *SCORPÆNIDÆ*.

With this family we come to a group easily distinguished from all the preceding representatives of this section by the articulation of the preopercular bone with the orbit by means of a projecting process from the infraorbital ring. Some of the other bones of the head are also armed, and the dentition is but feebly developed. These fishes, which are represented by a large number of genera, are found in most seas, and are all carnivorous in their habits. Dr. Günther writes that "some resemble the sea-perches in their form and habits, as *Sebastes*, *Scorpæna*, etc., whilst others live at the bottom of the sea and possess in various degrees of development those skinny appendages resembling the fronds of sea-weeds, by which they either attract other fishes, or by which they are enabled more effectually to hide themselves. Species provided with these appendages have generally a coloration resembling that of their surroundings, and varying with the change of locality. Some of the genera live at a considerable depth, but apparently not beyond three hundred fathoms. Nearly all are distinguished by a powerful armature, either of the head, or fin-spines, or both; and in some the spines have been developed into poison-organs." The group is scarcely known in a fossil state, although remains of a species of the typical genus occur in the Eocene of Algeria.

The family is divided into two sections, according as to whether there are distinct scales on the body, or whether these are rudimentary or wanting. In the former are included *Sebastes* and the typical *Scorpæna*. Most curious of all are the members of the Tropical Indo-Pacific genus *Pterois*, in which the spines of the dorsal and the rays of the pectoral fins are more or less produced,—so much so, indeed, that, in the case of one species at least, *P. volitans*, it was formerly thought that they indicated the possession of flying powers in their owner. The fins and body of this extraordinary-looking fish are most beautifully marked with alternating light and dark transverse bands. Among the genera with small or rudimental scales we have only space to mention the Oriental *Pelor* and *Choridactylus*, each represented only by a single species of 4 or 5 inches in length; and both of which are remarkable for the extraordinary development of the appendages mentioned above, some of these occurring on the fins, and others on the head and lower lip. The representative of the second genus is very common at Madras. It may be added that this family includes the smallest members of the suborder, which belong to the genus *Micropus*—a name probably belonging to the swifts. These fish scarcely exceed an inch and a half in length, and frequent the coral reefs of the Pacific.

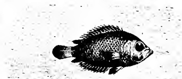
Allied Families. Of the three remaining and comparatively unimportant families, included in the perch-like section of the spiny-finned fishes, it is only possible to make very brief mention. The first of these, the *Nandidæ*, differs from all the foregoing by the incompleteness or absence of the lateral line, the dentition, although feebly developed, being more or less complete, and the preopercular bone having no connection with the orbit. The oblong and oval body is scaled: the number of spines in the dorsal fin is nearly equal to that of



BLEEKER'S PLESIOPS (½ nat. size).

the rays; the three-spined anal has its soft portion similar to the soft dorsal; and the thoracic pelvic fins have one spine and four or five rays. The small Oriental fresh-water fishes known as *Nandus*, *Badis*, etc., constitute a group of the family characterised by the presence of five rays in the pelvic fins, and the absence of false gills. They are common in all parts of India, some preferring ditches and inundated rice-fields, while others frequent clear streams. All are carnivorous, and the largest does not exceed 7 inches in length. The second group, as represented by *Plesiops* from the Indo-Pacific coral-reefs, and *Trachinops* from the Australian seas, although also including only small forms, are, on the other hand, marine; and are characterised by having only four rays to the pelvic fins, and by the presence of false gills. In *Plesiops* the lower rays of the pelvic fins are elongated and split at the ends; the soft dorsal and anal fins being likewise of considerable length. The figured species (*P. bleekeri*), which attains a length of 10 inches, is from the coral-islands of the South-West Pacific; it has the lateral line broken.

Polycentrus. The second family (*Polycentridæ*) is represented only by the genera *Polycentrus* and *Monocirrhus*, from the rivers on the Atlantic side of Tropical America, our illustration showing a member of the former genus (*P. schomburgki*). These fishes are characterised by the absence of a lateral line, and the great number of spines in both the dorsal and anal fins. The thoracic pelvic fins have one spine and five rays, and the teeth are feeble. These fishes are all of very small size, and are stated to feed exclusively upon insects.

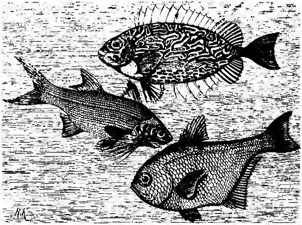


SCHOMBURGK'S MANY-SPINE (⅔ nat. size)

Teuthis. The single generic representative of the *Teuthididæ*, of which a species (*Teuthis striolata*) is shown in the illustration on p. 354, is characterised by the toothless palate, and the presence of a series of narrow serrated incisor teeth in the front of each jaw. The scales on the oblong and compressed body are very small, and there is a continuous lateral line. In the single dorsal fin the spinous considerably exceeds the soft portion in length; the anal has seven spines; and the thoracically-placed pelvic fins have an outer and inner spine, between which are three rays. These fishes have a large air-bladder, forked at both extremities, and they also display several peculiarities in the structure of the skeleton; the abdomen being surrounded by a complete ring of bones, owing to the backward prolongation of certain elements of the pectoral arch, and the unusual development of the pelvis. A considerable number of species have been described from the Indo-Pacific, where their eastward range stops about the longitude of the Sandwich Islands. The largest of them is not more than 15 inches in length, and all are vegetable-feeders. In the figured species, which is from the New Hebrides, the general colour is brownish red, marked with narrow vermiculated blue lines; the spines of the fins also bearing white spots.

THE BERYCOIDS OR SLIME-HEADS.—Family *BERYCIDÆ*

With the slime-heads we come to a family distinguished from the whole of the preceding, and forming a group by itself characterised by the presence on the head of large mucous-bearing cavities, covered with a thin skin and by the thoracically-situated pelvic fins having one spine and five rays (save in *Monocentris*, where the latter are reduced to two). The compressed body may be either oblong or deep in form, but is always short; and the scales, which are rarely wanting, are of the ctenoid type. Lateral in position, the eyes are almost always large in size; the lateral cleft of the mouth slopes obliquely upwards; the teeth in the jaws are villiform; teeth are in most cases developed on the palatines; the bones of the gill-cover are more or less fully armed; and there are nearly always eight branchiostegal rays, although these are sometimes reduced to four. There are no scales on the head, and false gills are present. The slime-heads, which comprise a considerable number of both living and extinct genera, are all marine fishes, with a practically cosmopolitan distribution, many of them living at great depths, and coming under the denomination of deep-sea fishes. They are also a geologically ancient group, represented by a large number of generic types, both existing and extinct in the Chalk and other Cretaceous deposits. The only existing forms that frequent the higher strata of the ocean belong to the genera *Holocentrum* and *Myripristis*; but even some species of the latter may descend as deep as one hundred and fifty fathoms. The typical genus *Beryx* has been taken from between three and four hundred fathoms; and from the small size of the eye the forms

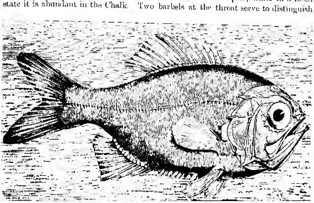


GROUP OF SPINE-FINNED FISHES.

Teuthis (upper figure), *Pempheris* (on the right), and *Polynemus* (on the left). (½ nat. size.)

known as *Melamphaes* must in Dr Gunther's opinion inhabit still lower levels. Another sign of their deep-water habits is afforded by the high development of the slime-secreting apparatus of these fishes.

Of the genera that space permits of our noticing, the most peculiar is *Monocentris*, represented by a single small and rare species from the seas of Japan and Mauritius, and distinguished by the absence of armatures on the gill-cover, the large size of the scales, which are articulated together so as to form a solid armour, and the reduction of the ventral fins to a single long spine, and a few rudimental rays. The fish figured in our illustration (*Trachichthys traillii*) represents a genus, with a few species from New Zealand and Madeira, characterised by the short and blunt muzzle, the prominent chin, the strong spine at the angle of the preopercular, the rather small scales, and the serration of the lower border of the body. The palatines and vomers carry villiform teeth; the single dorsal fin has from three to six spines, the anal six rays, and the tail is strongly forked. The allied *Anoplogaster*, of the Tropical Atlantic, is devoid of scales. In both genera the eye is very large. The typical genus *Beryx*, which has likewise but a single dorsal, may be distinguished by the smooth abdomen, and the lack of a spine on the preopercular. At the present day this genus is known from the Tropical Atlantic, Madeira, and the seas of Australia and Japan; while in a fossil state it is abundant in the Chalk. Two barbels at the throat serve to distinguish



NEW ZEALAND TRACHICHTHYS (½ nat. size)

Polymixia; while in several of the other genera, such as *Holocentrum*, the dorsal fin is double. Spread over all tropical seas, the latter genus is likewise one of those dating from the Cretaceous epoch.

Families *CURTIDÆ* and *POLYNEMIDÆ*

Each of these two unimportant families represents a group of equal rank with the perch-like division of the suborder; the first being characterised by having the single dorsal fin much shorter than the long and many-rayed anal. The compressed body (as shown in the figure of *Pempheris mangula*, on the right side of the illustration on p. 354) is oblong in form, deep in front, and sharply narrowing towards the tail. If developed at all, the spines of the short dorsal are few in number; the scales are small or medium in size; and both the jaws, palatines, and vomers bear villiform teeth. While the typical genus *Curtus* is confined to the Indian seas, *Pempheris* ranges over the Indian Ocean, the Malayan seas, and the tropical parts of the Pacific. The presence of a number of filaments, which may attain an enormous length, is the most distinctive feature of the second family, as shown in the example of the type genus (*Polynemus plebejus*), represented on the left side of the illustration last referred to; while a second characteristic is to be found in the two rather short dorsal fins, situated at a considerable distance from one another; and a third in the well-marked mucous-bearing canals on the head. The body is oblong and somewhat compressed, with smooth or slightly ciliated scales, and a continuous lateral line. The muzzle projects somewhat beyond the mouth, which is inferior in position, with a lateral cleft; and the large eyes are lateral. There are villiform teeth in the jaws and on the palate; and the pelvic fins are thoracic in position, with one spine and five rays. These fishes, which form three genera, include a number of species haunting the shores of tropical seas, and sometimes entering brackish or fresh water. Their filaments, which sometimes exceed twice the entire length of the head and body and can be moved independently of the pectoral fins, serve as feelers; and as these fish live in muddy water, and generally have their large eyes obscured by a film, the use of such accessory organs of touch is easily understood.

THE SCIÆNOIDS.—Family *SCIÆNIDÆ*.

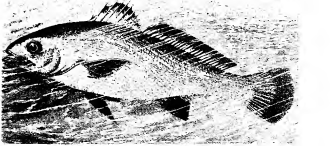
Of more general interest than the last is the family of Sciænoids, among which the umbrine of the Mediterranean and the widely distributed meagre are well known examples. In this group the spinous dorsal is abbreviated at the expense of the more or less elongated soft dorsal, which also exceeds the anal fin in length; and, although mucous canals are well developed on the head, there are no filaments near the pectoral fin. The somewhat elongated and compressed body is coated with ctenoid scales, and the uninterrupted lateral line sometimes continued on to the tail-fin. The long mouth is at the extremity of the muzzle; the eye is medium and lateral; and in addition to bands of villiform teeth, the jaws may carry tusks, although they are never provided with incisors or molars, and the palate is devoid of teeth. The preopercular bone is smooth, and without any bony connection with the orbit; and the thoracic pelvic fins carry one spine and five rays. Frequently the air-bladder is provided with a number of appendages. These fishes have a rather curious geographical distribution, being unknown in the Pacific and the Red Sea, but widely spread in the Atlantic and Indian Oceans, and especially common round the shores of India, where many species enter estuaries and rivers. Some species have, indeed, taken completely to fresh water, and never by any chance descend to the sea. Nearly all are eaten as food, and the air-bladders of many of the Indian forms are extensively used as a source of isinglass.

Drum.

The North American fish, rejoicing in the name of "drum" (*Pogonias chromis*), represents a genus characterised by the upper jaw of the convex muzzle overhanging the lower, the presence of numerous small barbels on the chin, and the absence of tusks. Ten stout spines form the first dorsal fin, and there are two spines in the anal, the hindmost of which is very strong. The scales are of moderate size; and there are a number of large flattened molar-like teeth on the pharyngeal bones. In length the drum often exceeds 4 feet, while it may scale upwards of 1 cwt. In what manner the extraordinary drumming sounds uttered by this fish, in common with other members of the family, are produced, does not appear to be ascertained, although it has been suggested that they may be due to the clapping together of the upper and lower pharyngeal teeth.

Umbrines The umbrine of the Mediterranean (*Umbrina cirrhosa*) whose range extends southwards to the Cape, was a fish well known to the ancients, and is a member of a genus containing about a score of species distributed through the Mediterranean, Atlantic, and Indian Oceans. Having an overlapping upper jaw, it differs from the last genus in the presence of but a single short barbel on the chin; while the first dorsal fin has ten flexible spines, and the anal either one or two. In size the typical species reaches about 3 feet.

Meagres The third genus that we notice (*Sciæna*) differs from both the preceding in the absence of any barbels; the cleft of the mouth being oblique and deep, and the eyes situated rather wide apart. The genus includes a very large number of species, with a geographical range equal to that of the family,



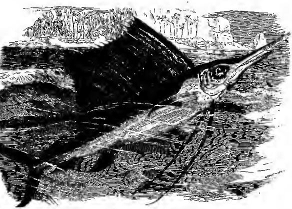
COMMON MEAGRE ([illegible] nat. size).

one of the best known being the typical meagre (*S. aquila*), ranging from the British coasts to those of the Cape and Australia. Although most of the species are smaller, this fish may attain a length of upwards of 6 feet. Yarrell states that the flesh of the meagre "appears always to have been in great request with epicures, and, as on account of its large size it was always sold in pieces, the fishermen of Rome were in the habit of presenting the head, which was considered the finest part, as a sort of tribute to the three local magistrates who acted for the time as the conservators of the city." It is certain members of this genus that have taken to a fresh-water existence.

THE SWORD-FISHES,—Family *XIPHIIDÆ*.

With this small and well-defined family, all the members of which attain very large dimensions, we come to our first representatives of purely pelagic fishes. Sufficiently distinguished from all their allies by the production of the upper jaw into the long, wedge-shaped, sword-like weapon from which they take their name, the sword-fishes are further characterised by the elongate and compressed body, the laterally placed eyes, and the deep cleft of the mouth. Teeth are either absent or rudimentary; and scales are likewise wanting, or represented merely by small rudimental structures. The dorsal fin is either single or divided, but has no distinct spinous portion; and the pelvis, if present at all, takes the form of long, rod-like, thoracically-situated appendages. There are seven branchiostegal rays, and no air-bladder is present. In the adult the sword is formed by the coalescence of the premaxillæ, vomer, and ethmoid, and is rough on the under surface from the presence of rudimental teeth. The sword-fishes are divided into the genera *Xiphias* and *Histiophorus*, according to the absence or presence of pelvic fins; these appendages in the latter being in the form of from one to three rays. There is considerable variation in the height of the dorsal fin, which is frequently so lofty as to project some distance above the water when the fish is swimming near the surface, and even, it is said, to answer the purpose of a sail. In the young, this fin is much higher in proportion to the length of the body than it is in the adult. In very young examples of the typical genus the beak is comparatively long, there are conical prominences on the edge of the supraorbital, the occiput is devoid of a spine, and there are two short, tooth-like processes at the angle of the preopercular. In *Histiophorus*, on the other hand, the beak at a corresponding age is much shorter; the supraorbital edge is finely denticulated, or smooth; and there is a bony spine on each side of the occiput, and at the angle of the preopercular. Although they are frequently not more than 4 to 6 feet in length, sword-fishes may measure as much as from 12 to 15 feet, and the sword itself may exceed a yard in length. The common European sword-fish (*Xiphias gladius*), which is occasionally taken on the British coasts, ranges from the European seas to the opposite side of the Atlantic; while to the southward it occurs off the northern and western coasts of Africa. *Histiophorus*, on the other hand, seems to be confined to the Pacific and Indian Oceans, ranging eastwards to Japan. Of the three Indian species, the spotted Indian sword-fish (*H. gladius*) is distinguished by the dorsal fin being much higher than the body, and marked with dark blue spots on a lighter ground of the same colour; the body being bluish grey above, and lighter beneath. On the other hand, in the black-finned sword-fish (*H. immaculatus*) the general colour of the body is dull grey, and the dorsal and anal fins are blackish. The third species (*H. brevirostris*) has the dorsal fin lower than the depth of the body; the general colour being grey, but the dorsal and pectoral fins tipped with black.

Mainly pelagic in their habits, sword-fishes are among the most predaceous and savage of the monsters of the deep, transfixing their ordinary prey, which includes cod and tunny, with their formidable sword, and likewise attacking whales with the same weapon. In such conflicts, the sword-fish, after making repeated stabs, generally comes out victorious, and the whale succumbs to his comparatively diminutive antagonist. Occasionally, however, one of these fishes appears to mistake a ship's bottom for a whale, and thereupon promptly charges it, sending the sword crashing through several inches of solid timber. In such cases it may happen that the sword-fish cannot withdraw its weapon, which is then broken off short in the struggles of its owner to escape. One thing we should like to see cleared up by actual observation, and that is, in what manner a sword-fish manages to remove from his weapon a cod, or other fish, which it has spitted. Instances are on record of these fish attacking and transfixing bathers; one such having occurred in the estuary of the Severn about the year 1830. Writing of one of the Pacific species, Colonel Pike observes that "this fish is a beautiful sight in the water. It has a habit of lying sunning itself on the surface when undisturbed, its dorsal fin is fully expanded and acting as a sail (and when needed it can propel itself at great speed), but it is only in the calmest weather it can be thus seen. It is frequently caught in deep water with hook and line, and when near the surface it is speared." When it feels the hook, or spear, a sword-fish takes tremendous leaps in the air, and if care be not exercised, will jump into



SPOTTED INDIAN SWORD-FISH ($\frac{1}{20}$ nat. size)

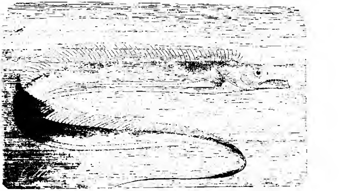
the boat of the fishermen. In the South Sea Islands young sword-fish are caught in strong nets, although no net will hold a fish of 6 feet in length. One of the most recent instances of a sword-fish attacking a ship occurred in the year 1874, on the voyage between Bombay and Calcutta. On this subject Frank Buckland writes that there is in the Museum of the College of Surgeons a section of the bow of a South-Sea whaler, in which "is seen the end of the sword of a sword-fish, measuring 1 foot in length and 5 inches in circumference. At one single blow the fish had lunged his sword through, and completely transfixed thirteen and a half inches of solid timber. The sword had, of course, broken off in the hole, and this prevented a dangerous leak in the ship. In the British Museum is a second specimen of a ship's side with the sword of a sword-fish fixed in it, and which has penetrated no less than twenty-two inches into the timber. When His Majesty's ship *Leopard* was repairing, in 1795, after her return from the coast of

Guinea, a sword of one of these fishes was found to have gone through the sheathing one inch, next through a three-inch plank, and beyond that four and a half inches into the firm timber; and it was the opinion of the mechanics that it would require nine strokes of a twenty-five-pound hammer to drive a bolt of similar size and form to the same depth into the same hull; yet this was accomplished by a single thrust of the fish." In the Mediterranean countries, where these fishes are commonly taken in tunny-nets, their flesh is exposed for sale in the markets. Geologically, the sword-fishes appear to be a comparatively modern group, the earliest known representatives, which have been assigned to the existing genus *Histiophorus*, occurring in the London Clay.

THE SCABBARD-FISHES AND HAIR-TAILS,—Family *TRICHIURIDÆ.*

Another group of equal rank with the perch-like section is formed by a family of fishes characterised by the elongate and compressed or even band-like form of the body; the mouth having a wide cleft, and several large conical teeth either in the jaws or on the palate. The dorsal and anal rays are long and many-rayed, with the spinous nearly equal in length to the soft portion, finlets sometimes occurring behind the latter; the pelvic fins, if present, are thoracic in position; and the caudal is sometimes wanting, but, when developed, forked. In all cases the scales are either rudimental or wanting, but the air-bladder is constant. These fishes are distributed over all tropical and subtropical seas; but while some are surface forms, never found at any great distance from the coasts, others descend to considerable depths in the open sea; all are carnivorous, and many very powerful. In India, writes Day, "these fishes are held in various estimation in different places. In Baluchistan, and where salt is cheap, no one will touch them; but along the coasts of India they are more esteemed, mostly because being thin or ribbon-shaped they can be dried without salting. In a fossil state these fishes date from the lower Eocene of Switzerland and other parts of Europe, where they are represented by extinct genera; species of scabbard-fish occur in the Sicilian Miocene, which has also yielded forms allied to the hair-tails (*Trichiurichthys*), but with the body sealed.

Scabbard-Fish. Among the better-known forms, the scabbard-fish (*Lepidopus caudatus*) represents a genus characterised by the absence or rudimentary condition of the pelvic fins, the long single dorsal, and the distinct but small tail-fin. Although it may attain a length of 5 or 6 feet, the attenuation of the body is so great that the whole weight does not exceed as many pounds. The fish has a very wide geographical distribution, ranging from the Mediterranean and warmer regions of the Atlantic to the Cape, and thence to New Zealand and Tasmania, while it occasionally wanders to the British coasts. This wide range may probably be taken as an indication that the scabbard-fish is a comparatively deep-sea form. In New Zealand, where it is known as the frost-fish, the scabbard-fish is highly esteemed for its flesh, which is white, rich, firm, and tender, with an excellent flavour. On this account, says an anonymous writer, "the fish is eagerly sought after, and commands a high price, as the supply is irregular, and not equal to the demand. Not much is yet known of the manners and customs of the frost-fish, but the little that has been made manifest is decidedly peculiar. It is a deep water fish, and yet, strange to say, has never yet been taken by the net, the rod, or the line. Even the all gathering trawl has hitherto failed to bring it to the surface of the deep. How then is its capture effected? To all appearance the frost-fish is captured by the fishermen only when it commits suicide and immolates itself on the sandy beaches of the Pacific. The facts are, that on calm and frosty nights, during the autumn and winter months, numbers of frost-fish come ashore alive through the surf on the beaches before referred to, and there wriggle on to the firmer sands above, to be devoured by the watchful sea-birds or picked up by the fortunate fisherman. No satisfactory reason has as yet been assigned for this rash act, although numerous theories have been propounded to account for it. One is that the hapless fish is pursued by a shark or other enemy, and prefers uncertain life on land to certain death at sea. Another and a more plausible theory is that the fish distends its air bladder to enable it to reach the surface for air or food, and that the keen frosty air there prevents it from compressing the bladder, and thus returning to its habitat under the waves. In this way the luckless fish gradually drifts into shallow water, and is washed ashore by the surf, only to struggle on to dry land to meet its fate. As may be imagined, the capture of the frost-fish has nothing specially sportsmanlike about it. The long sandy beaches some twelve miles from Dunedin are the favourite resort of the frost-fisher. The usual plan is to form a party of two or more, and camp out overnight at the foot of the cliffs which overhang the beach. Here a huge fire is lighted, and a tent pitched close at hand. The night, of course, must be clear and calm, as well as frosty, otherwise the long Pacific rollers make the surf too high for the successful capture of the game. The fishing itself is rather slow work, and consists merely in walking from end to end of the beach


SCABBARD FISH (1/3 NAT. SIZE).

shortly before dawn (the untimely hour chosen by the fish for self-destruction), and keeping a sharp look-out in the surf for the silver streak which betokens the advent of the frost-fish. When a fish is seen struggling in the waves or on the sand, all that remains to be done is to catch hold of it, and drag it up out of reach of the backwash (if it does not wriggle up by its own motion), and there despatch it with a stick or knife."

Hair-Tails. These scaleless fish (*Trichiurus*) take their name from the absence of a caudal fin, the body tapering posteriorly into a fine point. The single dorsal extends the whole length of the ribbon-like body; the pelvic fins are represented merely by a pair of scales, or are completely wanting; and the anal is rudimental, its spinous portion being reduced to a number of very small spines scarcely projecting above the skin. The jaws are provided with long tusks, and there are teeth on the palatine bones, although none on the vomer. Essentially tropical fishes, generally found in the vicinity of land, they appear to be sometimes carried by currents out to sea, which will probably account for the occasional appearance of the West Indian *T. lepturus* on the British coasts. These fishes attain a length of from 3 to 4 feet; and one of the Indian species is described as extremely voracious, preying on crustaceans and various fishes, among which members of its own kind are included.

Barracudas. The local name for a New Zealand representative (*Thyrsites atun*) of another genus may be taken as the popular title of all its members. These fishes, in which the rather elongate body is covered with minute scales, are characterised by having from two to six finlets behind the dorsal and anal, and the presence of teeth on the palatines. Barracudas, which grow to as much as 5 feet, form important food supplies in the Cape, South Australia, New Zealand, and Chili; when the flesh has been dried or otherwise preserved, it is exported from New Zealand in quantities to Mauritius and Batavia. The genus is unknown in the Indian seas, where the family is represented by the hair-tails.

Allied Extinct Forms. Two extinct genera, namely, *Palæorhynchus* from the Eocene of Switzerland, and *Hemirhynchus* from the Oligocene of France, represent a separate family (*Palæorhynchidæ*), distinguished from the last by the production of the muzzle into a long beak, which may be either provided with small teeth, or toothless. The dorsal fin occupies nearly the whole length of the compressed body; and the anal fin is also elongated, and extends nearly to the forked caudal.

THE SURGEONS,—Family *ACRONURIDÆ*

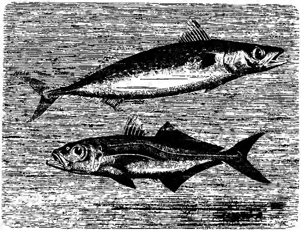
With this family we come to a group of spiny-finned fishes, including some thirteen others, which present the following characteristics in common. The dorsal fins are either placed together or continuous, the spinous portion being, when fully developed, shorter than the soft part, while it may be modified into tentacles, detached spines, or an adhesive disc; and the anal is similar in characters to the soft dorsal, and in some instances both these fins are modified posteriorly into finlets. The pelvic fins, if developed, are always thoracic or jugular in position, and are never modified into a sucker; and there are no papillæ in the neighbourhood of the vent. Nearly the whole of the members of the group are marine.

The first family is typified by a genus (*Acronurus*) the representatives of which are popularly known by the name of "surgeons," owing to the presence of a sharp lancet-like spine on each side of the tail in the adult. In addition to the presence of one or more such spines or bony plates, the family is further characterised by a single dorsal fin, with a very small number of spines. The body is compressed, and oblong or deep in form, with a covering of minute scales; the moderate-sized eyes are lateral in position; the small mouth is furnished in front with a single series of more or less compressed upper and lower incisors, which may be either pointed or serrated; but the palate is toothless. The pelvic fins are thoracic in position, and the hinder extremity of the air-bladder is forked. These fishes are inhabitants of all the tropical seas, and are most common in the neighbourhood of coral-reefs and islands, where some feed on the soft polyps of the coral, but others on various vegetable substances. In the true surgeons (*Acronurus*) there is an erectile spine situated in a groove on each side of the tail; and the pelvic fins are generally furnished with a single spine and five rays. In the young the body is scaleless, and the tail-spines either very small or wanting. These fishes are represented by a large number of species, the largest of which does not exceed 18 inches in length, and they are distributed over all tropical seas with the exception of the Eastern Pacific. In a fossil state the genus, like the next, occurs in the middle Eocene beds of Monte Bolca, in Italy. From the true surgeons the members of the genus *Naseus*, which range over the Tropical Pacific and the Indian Ocean, are distinguished by having from one to three non-erectile spines on each side of the tail, and the presence of only three rays in the ventral fins; while in some forms the head is armed with a forwardly-directed bony horn or crest-like prominence. The minute and rough scales make the skin like fine shagreen. A third genus (*Prionurus*) differs in having a series of keeled bony plates instead of spines on the sides of the tail. All the species of *Naseus* are said to be purely herbivorous. The true surgeons use their spines as formidable weapons of attack by erecting them and striking sideways with their tails.

The Horse-Mackerels,—Family *Carangidæ*.

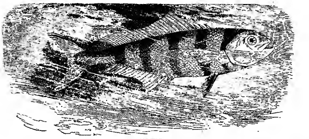
Although the name horse-mackerel properly applies only to a single British fish (*Caranx trachurus*), otherwise known as the scad, it may conveniently be made to do duty for the whole of the members of the family to which that species pertains. Having the body more or less compressed, these fishes are specially distinguished by the teeth, when present, being villiform or conical. The spinous portion of the dorsal fin is sometimes rudimental; the hinder rays of both the dorsal and anal may be broken up into separate finlets; and, when present, the pelvic fins are thoracic in position. In the skeleton there are ten trunk and fourteen tail vertebræ, although in one genus the number of the latter is increased to sixteen. The gill-openings are wide, the eyes lateral, and there is no bony stay connecting the preopercular with the infraorbital ring. The scales, which are usually small, may be altogether wanting; and in many cases the lateral line is wholly or partially armed with shield-like overlapping plates. There is always an air-bladder. In the young of some forms there is an armature of the head, which disappears in the adult. Carnivorous in their diet, the horse-mackerels are distributed at the present day over all temperate and tropical seas; and were also abundant during the Tertiary period, and likewise represented by extinct genera in the antecedent Cretaceous epoch. Remains of these fishes are found in extraordinary profusion in the middle Eocene strata of Monte Bolca, one of the most remarkable types from that formation being the extinct *Semiophorus*, in which the dorsal fin is so elevated as to exceed the total length of the head and body, while the pectorals formed a pair of backwardly-directed tapering spines.

True Horse-Mackerels. In the typical genus *Caranx* the body is generally more or less compressed, although sometimes almost cylindrical; the hard dorsal fin, which may be rudimentary, is continuous, with about eight weak spines; while in a few species the soft portion of both this and the anal is broken up into finlets. The scales are very small; and while in the British horse-mackerel (*C. trachurus*), represented in the lower figure of our illustration, the lateral line is protected by bony plates throughout its entire extent, in many other species these plates are restricted to its hinder moiety. Several of these plates may be traversed by a keel terminating in a spine. The genus is represented by nearly a hundred species, some of which have teeth on the palate, while in others these are wanting. Ranging over almost all temperate and tropical seas, many of them swim out to considerable distances from the shore, and thus acquire a very large distributional area. The larger forms may measure fully a yard in length; and the flesh of all



COMMON MACKEREL AND HORSE-MACKEREL (⅓ nat. size).

is edible. The genus is represented in the Monte Bolca Eocene. Horse-mackerel sometimes make their appearance in enormous shoals on the British coasts; and it is stated that on one occasion upwards of ten thousand were taken in Cornwall. A correspondent of Yarrell wrote, that in the summer of 1834 vast shoals of these fish were seen on the Glamorganshire coast. "They were first observed in the evening, and the whole sea, as far as we could command it with the eye, seemed in a state of fermentation with their numbers. Those who stood on some projecting rock had only to dip their hands into the water, and with a sudden jerk they might throw up three or four. The bathers felt them come against their bodies, and the sea, looked on from above, appeared one dark mass of fish. Every net was immediately put in requisition; and those which did not give way from the weight, were drawn on shore laden with spoil. One of the party who had a herring-seine with a two-inch mesh was the most successful; every mesh held its fish, and formed a wall that swept on the beach all before it. The quantity is very inadequately expressed by numbers, they were caught by cart-loads. As these shoals were passing us for a week, with their heads directed up channel, we had the opportunity of noticing that the feeding-time was morning and evening. They were pursuing the fry of the herring, and I found their stomachs constantly full of them."


PILOT FISH.

Pilot-Fish.

Another genus is represented by the pelagic pilot-fish (*Naucrates ductor*), which takes its name from a supposed habit of guiding and protecting the sharks and ships which it accompanies. Having no plates on the lateral line, this fish is further characterised by the rounded under surface of the body, by the first dorsal fin being composed in the adult of detached spines, by the absence of finlets, and the presence of a keel on each side of the tail. When adult, the pilot-fish measures about a foot in length. In colour it is bluish, with five or six dark vertical bands; the tail-fin sometimes having the ends of its two lobes dark, as also a band across the middle third. Ranging over all temperate and tropical seas, pilot-fish were regarded as sacred by the ancients, by whom they were known as *pompili*; the common belief being that when the ship neared land, the fish suddenly disappeared, and thus gave warning to the sailors of impending danger. Many legends have grown in later times as to how pilot-fish will prevent sharks from taking a bait by swimming round them and enticing them away; but all these appear to be pure fictions, and perhaps the best account of the real habits of the fish is one by Dr. Meyen, from which the following summary is taken. It appears that the pilot-fish constantly swims in front of the shark, sometimes coming close to its muzzle or front fins as it approaches a ship, and sometimes darting sideways or forwards for a short distance, and then returning to the side of the larger ship. In one instance, where a baited hook was thrown over the ship's side, the pilot-fish rushed up, and after swimming close to the bait, returned to the shark, and by swimming and splashing round it appeared to be attracting its attention. Soon after the shark began to move, with the pilot-fish in front, and was almost immediately hooked. Instead of the pilot-fish taking care of the shark it would rather seem to frequent the company of the latter for the sake of the fragments of food and other substances to be found in its neighbourhood; and it is doubtless for the same reason that these fishes follow ships. In summer, pilot-fish will not unfrequently accompany vessels into the southern British harbours; but their purely pelagic habits are indicated by the circumstance that their spawn and fry are found far out in the open sea. The young both of this fish and of some of the allied forms are so different in appearance from their parents that they have been described under distinct generic names.

Sea Bats

Both the preceding genera belong to a group of the family in which the spines of the anal fin are detached from its soft portion. As an example of a second group in which these two portions are connected by membrane we may notice the so-called sea-bats (*Platax*), remarkable for the great height and compression of the rhomboidal body, and the strong development of the dorsal and anal fins, which are often nearly similar in form and size. Indeed, except that they are symmetrical and have an eye on each side of the head, the sea-bats look almost like flat-fishes. They have the spinous portion of the single dorsal fin almost concealed, and with from three to seven spines; the anal has three spines; and the pelvic fins, which are sometimes greatly elongated, have a single spine and five rays. The scales are rather smaller or medium; the palate is toothless, and the jaws have a series of outer teeth somewhat larger than the small ones of the inner rows. These fish, of which there are but few species, appear to be confined to the Red Sea, Indian Ocean, and the Western Pacific, where they are abundant. Some of them attain a length of about 20 inches, and the body may be marked by a few broad vertical dark bands, the long lobes of the fins being black. In young specimens the rays of the median fins are proportionately much longer than in adults, thus giving the whole fish somewhat the appearance of a cheese-cutter. Sea-bats are found in a fossil state not only in the middle Eocene of Monte Bolca but likewise in the Cretaceous rocks of England and the Lebanon, so that the genus is an old one. In the allied genus *Psettus*, from the coasts of Western Africa and the Indo-Pacific Ocean, the pectoral fins are rudimental.

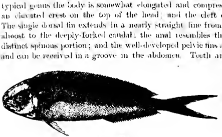
THE DORIES,—Family *CYTTIDÆ*

The deep form of the compressed body, the division of the dorsal fin into two distinct moieties, and the circumstance that the number of trunk-vertebræ exceeds ten, and that of the tail fourteen form the leading features by which the small family of the dories are distinguished from the other members of the group under consideration. The body may be invested either with small scales or bony plates, or may be devoid of both. The eyes are lateral, and the teeth conical and small. There is no connection between the preopercular and the orbit; the gill-opening is wide, and the pectoral fins are thoracic in position. The John Dory (*Zeus faber*), which gives the name to the family, and is said to derive its own title from a corruption of a foreign equivalent of "gilded cock," represents a genus with few species, characterised by a series of bony plates at the base of the dorsal and anal fins, and another on the under surface; the anal having four spines. The eight or nine spines of the first dorsal fin, which is not much shorter than the second, are produced into long slender filaments; and there are but few or no scales. The genus ranges over the Mediterranean, the eastern coasts of the temperate zones of the Atlantic, and the Australian and Japanese seas; while in a fossil state it occurs in the Miocene deposits of Sicily. An exceedingly ugly and ill-favoured creature, with a huge protruding mouth, the common dory is olive-brown tinged with yellow in colour, showing blue and metallic reflections in certain lights. The sides bear a large black spot, surrounded by a white ring; a similar mark occurring in some of the other species. A somewhat migratory fish on the British coasts, the dory has been long esteemed by epicures, and it is stated that its flesh is better on the second than on the first day. Couch writes that "when the pilchards approach the shore, the dory is often taken in considerable numbers. In the autumn of 1829 more than sixty were hauled on shore at once in a net, some of them of large size, and yet the whole of them were sold for nine shillings. It continues common until the end of winter, after which it is more rare but never scarce. The form of the dory would seem to render it incapable of much activity; and it is sometimes seen floating along with the current rather than swimming; yet some circumstances favour the idea that it is able to make its way with considerable activity. It keeps pace with shoals of pilchards so that some are usually enclosed in the seine with them; it also devours the common cuttle, a creature of vigilance and celerity; and I have seen a cuttle of a few inches long taken from the stomach of a dory that measured only 4 inches." In the allied genus *Cyttus*, represented by three species, from Madeira, South Australia, and New Zealand, the body is covered with minute scales, there are no bony plates, the number of spines in the anal fin is two, and the pelvic fins comprise one spine and six or eight rays.

STROMATEIDS AND CORYPHÆNAS,—Families *STROMATEIDÆ* and *CORYPHÆNIDÆ*

These two families are collectively distinguished from the preceding by the absence of any distinct spinous portion to the dorsal fin, the compressed body being either oblong, or very deep; and there being more than ten vertebræ in the trunk, and more than fourteen in the tail. In the first of the two the dentition is feeble, the palate being devoid of teeth; but there are horny barbed processes projecting into the œsophagus which take the place of oral teeth. The scales are very small, the eyes lateral, and the dorsal fin long. The typical genus *Stromateus*, which includes about half a score species from most tropical and temperate seas, is characterised by the absence of pelvic fins in the adult; the dorsal and anal fins being long with their points curving backwards in several of the species, and the caudal deeply forked. In habits these fishes are partly pelagic.

Coryphænas. The second of the two families is represented typically by the well-known pelagic coryphænas (*Coryphæna*), popularly miscalled dolphins. As a family, the *Coryphænidæ* are readily distinguished from the *Stromateidæ* by the absence of tooth-like processes in the œsophagus. In the typical genus the body is somewhat elongated and compressed, the adults having an elevated crest on the top of the head, and the cleft of the mouth is wide. The single dorsal fin extends in a nearly straight line from the back of the head almost to the deeply-forked caudal; the anal resembles the dorsal in having no distinct spinous portion; and the well-developed pelvic fins are thoracic in position, and can be received in a groove in the abdomen. Teeth are present in the jaws, as well as on the vomer, palatines, and tongue; the cycloid scales are small; and there is no air-bladder. The coryphænas, of which there are some half-dozen species, are purely pelagic fishes, ranging over all temperate and tropical seas, and remarkable for the beauty of their fleeting colours. Dr Günther observes that so "far as the colours are capable of description, those of the common species (*C. hippurus*), which is often seen in the Mediterranean, are silvery blue above, with markings of a deeper azure, and reflections of pure gold, the lower-parts being lemon-yellow, marked with pale blue. The pectoral fins are partly lead colour, partly yellow; the anal is yellow, the iris of the eye golden. These iridescent colours change rapidly whilst the fish is dying, as in the mackerel. The form of the body, and especially of the head, changes considerably with age. Very young specimens, from 1 to 6 inches in length, are abundant in the open sea, and frequently obtained in the tow-net. Their body is cylindrical, their head as broad as high, and the eye relatively very large, much longer than the snout. As the fish grows the body is more compressed, and finally a high crest is developed on the head, and the anterior part of the dorsal fin attains a height equal to that of the body." This species ranges over all tropical seas, and attains a length of from 5 to 6 feet; although its flesh is unpalatable to Europeans, it is eaten by the natives of Madras. Powerful swimmers, and associating in large shoals, coryphænas are determined enemies to flying-fish, pursuing them as they skim from wave to wave, and capturing them as they again fall into the water.



CORYPHÆNA.

Sun-Fish. As an example of genera in which the body is much compressed, short, and deep, we may select the sun-fish (*Lampris luna*) of the North Atlantic and Mediterranean, the sole representative of its genus. The body is covered with very small deciduous scales, the mouth has a narrow cleft, and is devoid of teeth, the dorsal has its anterior portion elevated into a narrow point, and the pelvic fins are composed of numerous rays. This fish, which attains to the length of 4 feet, is remarkable for the beauty of its coloration, the body being bluish, with round silvery spots, and the fins brilliant scarlet. Its flesh is reported to be of good flavour. In the allied *Mene*, also represented by a single species (*M. maculata*), inhabiting the Indian and Malayan seas, and attaining a length of 8 or 9 inches, the jaws are toothed, the mouth is very protractile, and the first rays of the pelvic fins are greatly elongated. This genus is found in a fossil state in the middle Eocene of Monte Bolca; while in the London Clay we have the extinct *Goniognathus*.

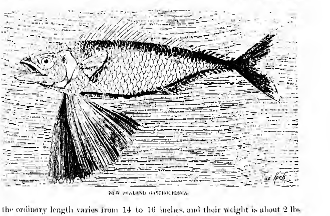
NOMÆIDS AND MACKERELS.—Families *NOMÆIDÆ* and *SCOMBRIDÆ*.

Both these families agree in having two dorsal fins, and in the number of trunk-vertebræ exceeding ten, and the caudal fourteen. In the first small and comparatively unimportant group there may be finlets behind the dorsal and anal fins; the dorsal has a distinct spinous portion, the caudal is forked, and the body covered with cycloid scales of moderate size. All these fishes are marine, and, in the young state at least, pelagic. Of the better-known genera, *Gastrochisma*, with a broad cleft to the mouth, finlets on the back and abdomen, and enormous pelvic fins, capable of being folded into a cleft in the body, and of which the position is thoracic, is known by a single New Zealand species (*G. melampus*). On the other hand, *Nomeus*, with two species from the Tropical Atlantic and Indian Ocean, lacks finlets, and has a narrow mouth-cleft.

Mackerels

The second of the two families is typically represented by the true mackerels (*Scomber*), and is characterised by the oblong or slightly elongated form of the body—which is but very slightly compressed, and covered either with very minute scales, or naked—and the structure of the dorsal fins. The first of these may be either modified into free spines or an adhesive disc, or the posterior dorsal, together with the anal, is split up into finlets. There may or may not be an air-bladder. Characterised by their beautiful protective coloration, which is some shade of bluish green, mottled or barred with black above, and iridescent silver beneath, the members of this family are all pelagic and carnivorous fish, associating in shoals, which may be of immense size, and frequenting all tropical and temperate seas. To enable them to keep up their constant rapid movements, their muscles, which are consequently red in colour, receive a much more abundant supply of blood than is the case with other members of the class, and their temperature is thereby raised several degrees higher. Although spawning in the open sea, at certain times of the year they make periodical migrations towards the shore in pursuit of the shoals of herrings and their fry on which they so largely subsist. In time, the family dates from the lower Eocene deposits of Switzerland, where it is represented by several extinct genera, and likewise by a species of sucking-fish, while many of the other existing genera occur in the latter deposits.

The true mackerels are characterised by the first dorsal fin being continuous, with feeble spines; the presence of five or six finlets behind the dorsal and anal; the very small scales, which are evenly distributed over the body; the small size of the teeth; and the two short ridges on each side of the caudal fin. Although there are but very few species of mackerel, these have a very wide range, and the genus is represented throughout the temperate and tropical seas, with the exception of the Atlantic seaboard of Temperate South America. The general coloration and form of mackerels are too well known to call for description, and it will suffice to mention that of the three European forms the common mackerel (*S. vernalis*)[1] has no air-bladder, while the southern mackerel (*S. pneumatophorus*) takes its name from the presence of that organ, which likewise exists in the Spanish mackerel (*S. colias*). In a fossil condition this genus occurs in the European Eocene and Miocene deposits. Of the common mackerel, which is represented in the upper figure of the illustration on p. 364, Yarrell writes that



NEW ZEALAND GASTROCHISMA.

"the ordinary length varies from 14 to 16 inches, and their weight is about 2 lbs. each; but they are said to attain the length of 20 inches, with a proportionate increase in weight. The largest fish are not, however, considered the best for table. As an article of food, they are in great request, and those taken in the months of May and June are generally considered to be superior in flavour to those taken either earlier in the spring or in autumn. To be eaten in perfection, this fish should be very fresh." The enormous takes of mackerel which occasionally reward the labours of British fishermen are too well known to need mention.

Tunnies. Under this general title may be included not only the fish to which the name tunny (*Thynnus mediterraneus*) properly pertains, but likewise those commonly designated bonitos and albicores. The genus, which comprises some of the largest of all pelagic fishes, differs from the true mackerels by the greater number (six to nine) of finlets, by the scales forming a kind of

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[1] The author can neither admit the combination *Scomber scomber* as the title of this fish, nor that of *Thynnus thynnus* for the tunny.

corselet on the anterior part of the body only, and the presence of only a single **longitudinal** ridge on each side of the tail. The tunnies have a geographical **distribution** coextensive with that of the family; and in a fossil state are found **in the Eocene** and Miocene deposits of the Continent. The common species, which **attains** a length of over 10 feet, and a weight of half a ton, is an occasional visitor **to the British** coasts, and is abundant in the Mediterranean, where it has been **regularly** fished for since very early times. At the present day specimens of a **hundredweight** each may often be seen in the Lisbon market; their flesh, which **is as red** as beef, being cut up and sold by weight. The bonito (*T. pelamys*) is a **smaller** and more slender fish, rarely exceeding a yard in length, and frequenting **all** temperate and tropical seas; while the name of albicore is applied to species like *T. albicora* of the Atlantic, characterised by the great length of their pectoral fins, some of these fish attaining a length of 6 feet. Albicore and bonito will follow in the wake of sailing-ships for weeks together. They prey largely on flying-fish, and Bennett writes of one species that it was interesting "to mark the precision with which it swam beneath the aeronaut, keeping him steadily in view, and preparing to seize him at the moment of his descent. But this the flying-fish would often elude by instantaneously renewing his leap, and not unfrequently escape by extreme agility." Moseley writes that, when at St. Vincent, he saw a tunny of some 25 lbs in weight attracted by baits thrown into the water by some negroes, who kept on casting in fresh ones for some time, in order to give their victim confidence. "A very strong piece of cord, with a hook like a salmon-gaff made fast to it, was then baited with a small fish, just enough to cover the point of the hook, and a stout bamboo used as a rod. The cord was hitched tight round one end of it, with about a foot of it left dangling with the hook. One negro held the rod, and another the cord, the bait being held just touching the surface of the water. The fish swam up directly, and took it; the negro holding the bamboo struck sharply, and drove the big hook right through the fish's upper jaw, and both men caught hold of the line and pulled the fish straight out on to the rock." This instance indicates the remarkable boldness and voracity of the tunnies, the fish in question not being six feet distant from the negro holding the pole when it took the bait. Passing over several allied genera, such as *Pelamys* and *Cybium*, we proceed to a more interesting group of the family.

Sucking-Fishes.

The remarkable adhesive disc on the upper surface of the head at once serves to distinguish the sucking-fishes, not only from their immediate relatives, but likewise from all other members of the class; and it may be mentioned that the development of this disc by means of what is called natural selection presents one of the strongest objections to the acceptance of that doctrine, since in its incipient stages such a structure would be utterly useless. The genus *Echeneis*, to which all the half-score species of sucking-fish pertain, differs from all those noticed above in the absence of finlets; the sucking-disc being formed by a modification of the spines of the dorsal, and being composed of a number of transverse plates, varying from twelve to twenty-seven, according to the species. It is not a little remarkable that there exists in the Indian Seas, as also in the Tropical Atlantic, a fish (*Elacate nigra*) closely allied to the sucking-fishes but with the disc represented by a few short and separated spines; and it may be considered certain that this fish is the survivor of the ancestral type from which its more specialised relatives have been evolved. The body of the sucking-fishes is elongate and pyriform; the eyes are lateral, or directed downwards and outwards; and the cleft of the mouth is deep. Villiform teeth are present, not only in the jaws and on the bones of the palate, but generally also on the tongue; the scales are minute; and there is no air-bladder. The second dorsal and anal fins are elongated, and the pelvics thoracic in position. Both in this genus and *Elacate* the shape of the caudal fin is subject to considerable change with age; the middle portion in the young being produced into a long filament which gradually shortens until a rounded margin is produced. At the time of the full development of the fish the corners of the tail have, however, grown out, so as to convert the rounded fin into an emarginate or forked one. Of the two most common members of the genus, *Echeneis remora* which is the one represented in our illustration, is comparatively small, growing only to a length of about 8 inches; whereas *E. naucrates*, characterised by the slenderness of its form, may reach a yard in length. Sucking-fishes are inhabitants of nearly all seas and in a fossil state are found in the lower Eocene deposits of Switzerland.

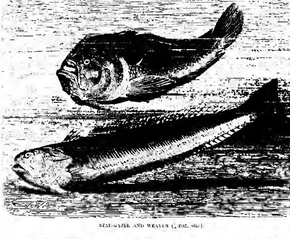
SUCKING-FISHES (⅓ NAT. SIZE).

Sucking-fishes are commonly found attached to the bodies of sharks, although they may affix themselves either to turtles or ships; and as they are carried by their involuntary hosts through a much greater extent of water than their limited powers of swimming would admit of their traversing by themselves, they naturally obtain a much greater supply of food than would otherwise be possible. The erection of the plates constituting the sucker produces a series of vacua, by means of which the adherence is effected; and so strong is the adhesion that it is very difficult to remove one of these fishes except by sliding it along the surface to which it is attached. Moseley remarks that in shark-fishing the suckers sometimes drop off as the shark is hauled on board, and sometimes remain attached; and that when a shark is hooked and struggling in the water, they may often be seen to shift their position. He adds that as it is the back of the sucking-fish that is applied to the body by which it is transported, this "being always less exposed to light is light-coloured, whereas the belly, which is constantly outermost and exposed, is of a dark chocolate colour. The familiar distribution of colour existing in most other fish is thus reversed. No doubt the object of this arrangement is to render the fish less conspicuous on the brown back of the shark. Were its belly light-coloured, as usual, the adherent fish would be visible for a great distance against the dark background. The result is that when the fish is seen alive, it is difficult to persuade oneself at first that the sucker is not on the animal's belly, and that the dark exposed surface is not its back. The form of the fish, which has the back flattened and the belly raised and rounded, strengthens the illusion. When the fish is preserved in spirits, the colour becomes of a uniform chocolate, and this curious effect is lost. When one of these fish, a foot in length, has its wet sucker applied to a table, and is allowed time to lay hold, it adheres so tightly that it is impossible to pull it off by a fair vertical strain." When they have lost their shark these fish often attach themselves to a ship, which they probably mistake for a large individual of that race. It has been stated that certain races are in the habit of employing sucking-fishes for the capture of turtles. This curious mode of fishing is practised by the natives of Zanzibar, Cuba, and Torres Straits.

STAR-GAZERS AND WEAVERS,—Family *TRACHINIDÆ*.

According to the arrangement adopted by Dr Günther, the eighth family of the group under consideration is taken to include not only the typical weavers, but likewise the star-gazers and several other more or less nearly allied types, these being split up into five subfamilies. On the other hand, Day prefers to regard some if not all of these subfamilies as the representatives of distinct families; but in a work of the present nature it will be more convenient to treat the whole of them together. In this wider sense the family is characterised by the more or less elongated and narrow form of the body, which may be either naked, or have scales. A spinous dorsal, or a spinous portion of the dorsal, is generally distinct, in which the spines are connected by membrane; there are no finlets; the caudal (except in the tile-fish) is not forked; the pelvic fins include a single spine and five rays; and the gill-openings are more or less wide. The number of vertebræ in the trunk is generally ten or more, and there are always more than fourteen in the tail. As a rule the members of this family agree with those of the preceding families of the group in the absence of a bony stay connecting the preopercular bone with the orbit, but in the genus *Pseudochromis* and its allies such a connection exists. Carnivorous in their habits, the majority of these fishes are of small size, with but feeble swimming powers, and living on the bottom of shallow seas. The tile-fish and its allies are, however, large deep-water forms, and the genus *Bathydraco* has been taken from depths of over 1200 fathoms. They inhabit all seas except the Arctic, where they are almost unknown.

Star Gazers. The star-gazers, as typically represented by the genus *Uranoscopus*, of which one species (*U. scaber*) is shown in the upper figure of the accompanying illustration, form the first subfamily, and take their name from the upward direction of their small eyes, which are situated on the upper surface of the head. They are further characterised by the continuous lateral line, and by the spinous portion of the single or double dorsal fin being less

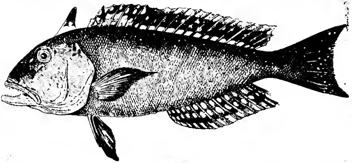


STAR-GAZER AND WEAVER (¼ nat. size).

developed than the soft part, which is similar to the anal. The members of the typical genus are distinguished by the large, broad, and massive head being partly covered with bony plates; the vertical cleft of the mouth; and the minute size of the scales. The first of the two dorsal fins has from three to five spines, and the rays of the pectorals are branched. Villiform teeth are present in the jaws and on the bones of the palate, but there are no tusks. The gill-cover is armed; and there is generally a long filament below or in front of the tongue, but there is no air-bladder. While the figured species is from the Mediterranean, the others range from the Indo-Pacific to the Atlantic. Rarely measuring a foot in length, these exceedingly unprepossessing fish can raise or depress their small eyes at will, and are generally found lying sluggishly on the sea-bottom in wait for their prey, frequently concealed among stones. The filament in front of the mouth, which is moved by the stream of water continually passing through the latter, doubtless acts as a lure to entice the small creatures on which these fishes feed. In the allied *Leptoscopus* of New Zealand, and *Ichthyoscopus*, ranging from India to Japan, there is but a single dorsal fin; the latter genus agreeing with the true star-gazers in having bony plates on the head, whereas in the former the whole head is invested in a smooth skin. The Indian *I. inermis* attains a length of 2 feet, and is stated to live in the mud.

Weavers. The common English weaver, or sting-bull (*Trachinus draco*), shown in the lower figure of the illustration on p. 374, is the best known representative of the typical genus of the second subfamily, in which the eyes are more or less lateral in position, the lateral line continuous, and the hinder-part of the premaxillary bones devoid of an enlarged tooth; the dorsal fins being one or two in number. In this particular genus the cleft of the mouth is very oblique; the eyes have an upward inclination; the cycloid scales are very small; and there are villiform teeth both in the jaws and on the bones of the palate. Of the two dorsal fins, the first is very short and furnished with six or seven spines; and the lower rays of the pectorals are simple. In the head both the preorbital and preopercular bones are armed. The weavers have a somewhat peculiar geographical distribution, being found in the European seas, but unknown on the Atlantic coasts of America, although reappearing in Chilian waters. In the British seas they are represented by the greater weaver (*T. draco*), frequently measuring about a foot in length, and the lesser weaver (*T. vipera*), which seldom exceeds 6 inches. Yarrell writes that "the great weaver generally measures about 12 inches in length, but has been known to attain 17 inches; its food is the fry of other fishes, and its flesh is excellent. It swims very near the bottom, is sometimes taken in deep water by the trawl-net, and occasionally with a baited hook attached to deep-sea lines. When caught it should be handled with great caution. I have known, says Mr. Couch, three men wounded successively in the hand by the same fish, and the consequences have been in a few minutes felt as high as the shoulder. Smart friction with oil soon restores the part to health, but such is the degree of danger, or apprehension of it rather, arising from wounds inflicted by the spines of the weavers, that our own fishermen almost invariably cut off the first dorsal fin and both opercular spines before they bring them on shore." The poisonous secretion, which is a modification of the ordinary mucus, is lodged in a deep double groove in the spines of the dorsal fin and gill-cover. There are numerous other genera of the subfamily, among which the above-mentioned *Bathydraco* is noteworthy as being a deep-sea fish.

Tile-Fish. The third subfamily—regarded by many writers as a distinct family under the name of *Latilidæ*—has been long known by the genera *Latilus* and *Pinguipes* from various tropical and subtropical seas, and is characterised by the body being covered with small scales, the lateral position of the eyes, the continuous lateral line, and the presence of a large tooth on the hinder part of the premaxillary bones. Especial interest attaches to the group on account of the discovery of a new member off Nomans Land, Massachusetts, in 1879, which received the name of tile-fish (*Lopholatilus chamæleonticeps*). An interesting account of this fish is given by Mr. B. Phillips, who, after mentioning that the first example was taken by the captain of a fishing-smack when working cod-lines in deep water, goes on to observe that the tile-fish was one of the most brilliantly-coloured fishes out of the tropics, and remarkable for the presence of a soft dorsal fin resembling that of the salmon, which is placed on the neck in advance of the regular dorsal fin instead of behind it as in the salmon family. In the U.S. Fishing Report of 1881, it is stated that "there is every reason to believe that the tile-fish will rank among the most important food-fishes of the United States." The fish would weigh from 10 lbs. to 40 lbs., and its abundance was remarkable. It took the hook readily, and in an hour or two a catch of 250 lbs. of tile-fish was not uncommon. As the lines used were the same as for cod-fishing, no change of apparatus was necessary. It was then believed that this new fish would singularly increase the food-supply of the North Atlantic Coast; but just when American fishermen were beginning to apply their skill to the catching of tile-fish off the New England coast, the *Lopholatilus* disappeared.



TILE-FISH.

Other Groups.

Two other subfamilies, distinguished by the lateral line being interrupted or stopping short of the caudal fin, are severally typified by the genera *Pseudochromis* and *Notothenia*, the former subfamily having the dorsal fin continuous, while in the latter it is divided. *Pseudochromis* and certain other genera include tropical fish frequenting coral-reefs or coral-coasts, and taking their name from their superficial resemblance to the members of a very different family—the *Chromididæ*. They differ from all the allied forms in having a bony stay connecting the preopercular bone with the infraorbital ring.

SOFT-SPINES AND FROG-FISHES.—Families *MALACANTHIDÆ* and *BATRACHIDÆ*.

Of these two unimportant families, the first is represented solely by the soft-spines (*Malacanthus*), and differs from the preceding family by having only ten trunk and fourteen tail-vertebræ. The body is elongated, and covered with very small scales; the mouth has very thick lips; and the premaxillæ have a large tooth behind. The dorsal fin is single, and, like the anal, greatly elongated; its anterior portion having a few simple rays. There is one spine to the five-rayed pelvic fins; and the gill-membranes are united beneath the throat, the gill-cover being armed with a spine. Of the three tropical species constituting this genus, the one here figured (*M. haedti*) is distributed through the Indian and Pacific Oceans, from Mauritius to the Sandwich Islands; the second has a nearly similar range; but the third is found on the Atlantic coast of Tropical America.

Frog Fishes. Frog-fishes (*Batrachus*) may be taken as our representatives of the second of the two families under consideration. The family to which they belong is characterised by the distinct spinous portion of the dorsal fin which includes a few pungent spines, while the pelvic fins have one spine and only two soft rays. The head is broad, thick, and frog-like; the body elongate, and compressed behind; and the skin either completely naked, or covered with small scales; the conical teeth being of small or medium size. The soft dorsal and anal fins are elongated, and the pectorals simple; the rather narrow gill-opening forming a more or less nearly vertical slit in advance of the latter, and the opercular bones being armed. An air-bladder is invariably present. All the members of the family are of small size and carnivorous habits, living on the sea-bottom and often ascending tidal rivers; but, while the majority are confined to the tropics, a few range into the warmer parts of the temperate zones. As a genus, the true frog-fishes are characterised by the spinous portion of the dorsal fin having three strong spines, and the presence of several spines on the gill-cover; while in many species the margins of the mouth, as well as other parts of the head, are provided with shining tentacles. Out of about a dozen species, one (*B. didactylus*) occurs in the Mediterranean. Some of the species have a poison-gland under each pectoral fin; and at Penang all the tribe are regarded as highly poisonous, although in Bombay their flesh is eaten by the poorer classes of natives. The poison-gland attains its highest development

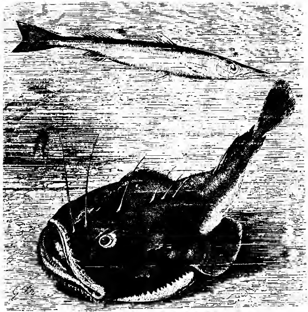
HAEDT'S SOFT-SPINE (⅔ nat. size).

in a species from the Pacific coast of Panama, described under the name of *Thalassophryne*, in which it is stated to be as perfect as in the venomous snakes. In this fish each opercular bone terminates in a long spine similar to those of the dorsal fin, these spines being perforated by a canal having an aperture at their base and summit. This canal communicates with a sac containing the poisonous secretion, which can be made to flow out through the spine by pressure.

ANGLER-FISH AND THEIR ALLIES.—Family *LOPHIIDÆ.*

Passing over one very unimportant family, our next representatives of the group under consideration are the angler-fish and their allies, a family remarkable for their extreme ugliness and strange forms. Possessing the group-characters already noticed, they are specially distinguished by having the spinous dorsal fin placed far forwards on the head, and generally modified more or less completely into tentacles, although it may be represented by isolated spines. The head and fore-part of the body are of enormous relative size, and the teeth in the capacious mouth are either villiform or rasp-like. When present, the pelvic fins consist of four or five soft rays; and the pectorals are supported by a prolongation of some of the superior bones. The gill-opening is reduced to a small aperture situated near the pectoral fin, and the gills themselves are either two and a half or three and a half in number, false gills being generally absent. These fish are distributed over all seas. Dr. Günther writes that "the habits of all are equally sluggish and inactive; they are very bad swimmers; those found near the coasts lie on the bottom of the sea, holding on with their arm-like pectoral fins to seaweeds or stones, between which they are hidden; those of pelagic habits attach themselves to floating seaweed or other objects, and are at the mercy of wind and current." A large proportion of the genera have, therefore, found their way to the greatest depths of the ocean retaining all the characteristics of their surface-ancestors, but assuming the modifications by which they live in abysmal depths.

Anglers. The small number of species constituting the typical genus (*Lophius*) of the family include its ugliest representatives, among these being the British angler-fish (*L. piscatorius*), which also rejoices in the titles of fishing-frog, frog-fish, or sea-devil. Its leading characters are to be found in the enormous size of the broad, depressed, and rounded head, near the middle of the upper surface of which are situated the small eyes, and the great width of the cleft of the mouth, which looks like a yawning chasm. Both the jaws and palate are armed with rasp-like teeth of unequal size, capable of being raised and depressed at the will of their owner. The body is naked; the first three spines of the dorsal fin form long tentacles on the head, and the next three are connected, the soft dorsal and anal fins being of small length. Young specimens are exceedingly unlike their parents, having the head smaller, the tentacles branched, and most of the rays of the fins produced into long filaments. The whole of the few known forms are coast-haunting fishes, the common species ranging from the European and South African seas to those of the western side of North America; while a second is found in the Mediterranean, a third in Chinese and Japanese waters, and a fourth in those of the Admiralty Islands. In the British species the general colour of the upper surface is uniform brown, becoming darker on the fin-membranes; while the under-parts, as well as the pectoral and pelvic fins, are white; the tail being dark blackish brown. The colour is, however, subject to a certain amount of modification, according to the tint of the inanimate surroundings of the individual. Although commonly not more than a yard in length, specimens of this ugly monster have been known to measure more than



BARRACUDA AND ANGLER FISH (1/[illegible] nat. size).

5 feet. In all respects the angler affords us an example of a creature most admirably modified and adapted for the exigencies of its particular mode of life. Living on the mud or sand of a shallow sea-bottom, the angler is protected not only by its power of adapting its own coloration to that of its environment, but likewise by the fringed appendages surrounding the head presenting the appearance of a mass of seaweed. The structure of the paired fins renders the fish able to walk on the sea-bottom; and with these limbs it also stirs up at times the sand and mud to attract its prey, and at the same time to aid in concealing its own

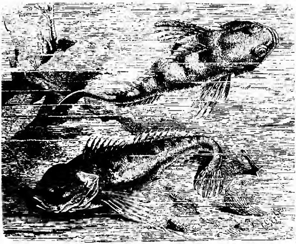
ugly person. Fish and other prey are also attracted by the constant movement of the first tentacle on the head, the summit of which terminates in an expanded lappet; and no sooner is the unfortunate victim well within reach, than it is engulfed with one snap of the capacious mouth; the erectile and backwardly-directed teeth preventing any chance of escape from this avernus.

Tentacle-Fish.

As an example of a pelagic genus of the family we select the tentacle-fish (*Antennarius*), so remarkable for their nest-building habits. In these fishes the large head is elevated and compressed; the cleft of the mouth being quite or nearly vertical, and of only moderate width. There are rasp-like teeth on the palate and jaws; the eyes are small and lateral; the body may be either naked, or covered with granules or spines, which may be modified into tentacles; and the head is furnished with three tentacles very similar to those of the true anglers. The soft dorsal is of moderate length, and the anal short; pelvic fins being present. Although chiefly tropical, these fishes are often carried far into the temperate seas; and many of them have a most extensive range, being found alike in the Pacific and Atlantic Oceans. Feeble swimmers, these fishes are not unfrequently to be found near the coast, where they conceal themselves beneath corals, stones, or seaweed, to which they hold fast by their arm-like pectoral fins. They have also been observed to hop over moist ground or slimy seaweed, and at times conceal themselves in the mud, after the manner of the true anglers, attracting their prey by the movements of the first tentacle on the head, the extremity of which, when in motion, much resembles a worm. When at sea, they have the power of inflating their bodies in the same way as the globe-fishes. It has been observed that one of these fishes placed in a basin containing a small quantity of water produced so strong a current by the passage of water through its jaws and its subsequent expulsion through the gill-orifice, that a rapid rotatory motion resulted. "The gulf-weed," writes Day, "assists the migration of these fishes; during the winter months the prevailing winds bring to the islands of the Bermudas large fields as well as isolated patches of weed, on which many fishes find a home, and among them *Antennarius*. Here it makes its wonderful nest, suspended by means of silk-like fibres, which prove strong enough to support the huge bunches of eggs that hang like grape-clusters within its orbicular case; and M. Vaillant has shown that each nest is made of one seaweed, the different twigs being brought together and made fast to each other by the fish by means of a pasty sort of substance provided by the animal itself."

THE BULL-HEADS AND GURNARDS.—Family *COTTIDÆ*.

The thirteenth family of the present section differs from all the foregoing, with the exception of the genus *Pseudochromis* and its allies, in the presence of a bony process arising from the infraorbital ring of the skull to connect it with the spine at the angle of the preopercular bone. In shape the body is more or less elongate and subcylindrical; the cleft of the mouth is transverse, and the weak teeth are generally arranged in villiform bands. As a rule there are two dorsal fins, of which the spinous is less developed than the soft; both the latter and the anal being elongated; the pectorals may be provided with filamentous appendages, and the pelvic pair have not more than five rays. The body may be either naked, scaled, or protected by a single row of plate-like scales. The members of this family, which are arranged under a good many generic heads, are distributed over almost all seas, while a few inhabit fresh waters. Of comparatively small or medium size, these fishes have but poorly developed swimming powers, and spend their time swimming or crawling at the bottom of the sea in shallow water at no great distance from the coast. A Japanese bull-head is stated, however, to have been dredged in five hundred fathoms of water. In a fossil state gurnards referable to the existing genus occur in many of the European Tertiary rocks; while remains of bull-heads are met with in the upper Miocene of Basle, and those of the allied extinct genus (*Lepidocottus*), distinguished by its ctenoid scales, in the upper Eocene of Switzerland.



COMMON BULL-HEADS (nat. size.)

Bull-Heads. The familiar bull-head or miller's thumb (*Cottus gobio*), of the streams of Britain and many other parts of Europe, belongs to a genus containing some forty species, mostly distributed over the fresh waters and coasts of the temperate zone of the Northern Hemisphere. All are of small size, and characterised by the broad, depressed, and rounded head; the subcylindrical body, somewhat compressed posteriorly; the absence of scales; the distinct lateral line; and the rounded pectoral fins, in which some or all of the rays are simple. Villiform teeth are present on the jaws and vomer, although there are none on the palatine bones. In the majority of the fresh-water species the spine on the preopercular bone is simple, but becomes branched in many of the marine forms. The common fresh-water species, which ranges over Central and Northern Europe to Northern Asia, seldom exceeds 4 or 5 inches in length, and is more generally found in small streams than in large rivers. It has a well-known habit of concealing its broad and flat head beneath loose stones on the river-bottom, and in this position will lie motionless for hours, but when disturbed swims swiftly away. Its food consists of the larvæ of water-insects and crustaceans, as well as the eggs and fry of other small fish. The other British representatives of the genus are all marine, and include the sea-scorpion (*C. scorpius*) and father-lasher (*C. bubalis*), both of which are also found on the opposite side of the Atlantic as well as two other less common species. The males of the common marine species are stated to build a nest of stones and seaweed for the reception of the spawn, and to guard and defend the young fry when hatched.

On the Indian and Australian coasts the bull-heads are represented by the so-called flat-heads, or crocodile-fishes (*Platycephalidæ*), in which the much depressed head is more or less fully armed with spines, and the body covered with ctenoid scales; the anterior spine of the first dorsal fin being isolated from the rest, and teeth present on both the vomer and palatine bones. Day writes of these fishes that "the wounds from their spines are dreaded because of the violent irritation they occasion. Their eyes are peculiar: the iris possesses two semicircular flaps, one above, the other below, the upper being usually the larger; these flaps can be brought close together, probably under the stimulus of light."

Gurnards

Of a decidedly ugly appearance, the gurnards (*Trigla*) are easily recognised by their enormous, square and elevated heads, in which the upper surface and sides are entirely bony, and likewise by the finger-like first three rays of the pectoral fins, which serve not only for walking on the sea-bottom but likewise as organs of touch. There are two dorsal fins, of which the spinous is tall, and the soft one long, low, and similar to the anal; the tail-fin being slightly rounded. The teeth are villiform; and the air-bladder, which is generally furnished with lateral muscles, may be divided into two longitudinal halves. They have been divided into three subgenera, of which the typical one is characterised by the absence of teeth on the palatines, and the small size of the scales, with the exception of the highly modified ones forming the lateral line, which are large, triangular, and spiny. The second group is distinguished by the median size of the scales; while in the third teeth are present on the palatine bones. Their colours are frequently brilliant, and the fins highly decorated. The genus is represented by some forty species, distributed over all temperate and tropical seas, out of which no less than seven are found in British waters. Their flesh, which is firm and flaky, and of a pale orange-pink tinge, is extensively used as food. One of the best known of the British species is the red gurnard (*T. pini*), which seldom exceeds 12 or 14 inches in length, and, when freshly caught, is of a bright red colour, with the sides and under-parts silvery white, and the fins reddish white. Its food consists of crustaceans, which give the pinkish tinge to its flesh, and the spawning-season is May or June. The sapphirine gurnard (*T. hirundo*), which is the one represented in the woodcut, is another British species, taking its Latin name from the length of the pectoral fins, and its English

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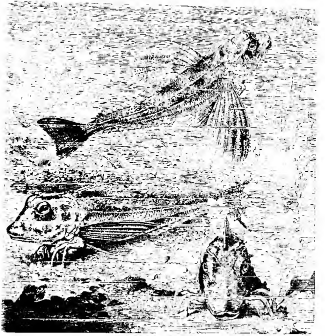
title from the beautiful azure tint of their inner surfaces. More abundant than the other species, this gurnard may reach a couple of feet in length, its general colour being brownish red. A third British form is commonly known as the piper (*T. lyra*), and may be recognised by the unusually large size of the head, the more projecting muzzle, and the greater length of the spines of the gill-cover. The general colour is brilliant red, with the under-parts white. It attains a length of a couple of feet, and is supposed to take its name from the grunting sound which, in common with other species, it emits when first handled, owing to the escape of air through the mouth. The European forms are rarely found on the other side of the Atlantic, where their place is taken by representatives of the third subgenus.



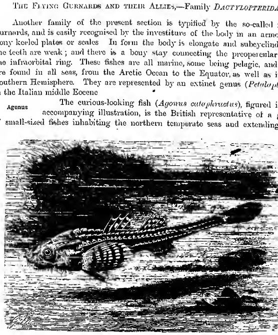
SAPPHIRINE GURNARDS (⅓ nat. size).

Two British species are figured in the coloured Plate, namely, the grey gurnard (*T. gurnardus*) above, and the streaked gurnard (*T. lineata*) below.

THE FLYING GURNARDS AND THEIR ALLIES,—Family *DACTYLOPTERIDÆ*.

Another family of the present section is typified by the so-called flying gurnards, and is easily recognised by the investiture of the body in an armour of bony keeled plates or scales. In form the body is elongate and subcylindrical; the teeth are weak; and there is a bony stay connecting the preopercular with the infraorbital ring. These fishes are all marine, some being pelagic, and they are found in all seas, from the Arctic Ocean to the Equator, as well as in the Southern Hemisphere. They are represented by an extinct genus (*Petalopteryx*) in the Italian middle Eocene.

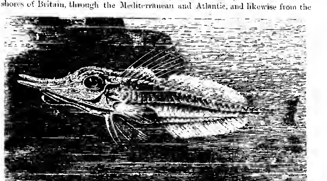
Agonus The curious-looking fish (*Agonus cataphractus*), figured in the accompanying illustration, is the British representative of a genus of small-sized fishes inhabiting the northern temperate seas and extending into



ARMED BULL-HEAD ([illegible] nat. size).

the Arctic Ocean. They are characterised by the angulation of the head and body, which are inv[illegible]in bony plates; the small size of the teeth in the jaws; the two dorsal fin[illegible] the absence of appendages to the pectorals. Of the armed bull-head, as the British species is popularly termed, Yarrell writes that it is not "uncommon along the line of our southern coast, where it is well known; and the young of small size are frequently taken by the shrimpers in most of the sandy bays at the mouth of the Thames and of other rivers; on the eastern coast it is very plentiful. It seldom exceeds 6 inches in length: its food is aquatic insects and crustaceans; it spawns in May, depositing the ova among stones, and its flesh is said to be firm and good." Somewhat curiously, an outlying representative of the genus occurs on the Chilian coast.

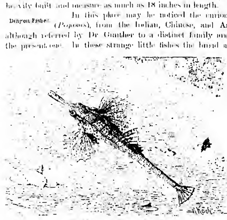
Beaked Gurnards. As a genus remarkable for the singularity of their form, we may briefly notice the beaked gurnards, of which the European representative (*Peristethus cataphractum*) is shown in our illustration. These rather small fishes are specially characterised by the preorbital bone being prolonged into a flattened process projecting on each side beyond the muzzle: the whole of the squared head being invested in a solid bony case. Large plates of bone form the body-armour; the dorsal fin may be either continuous or divided into two moieties, of which the second is the longer; there are two free appendages in advance of each pectoral fin; teeth are wanting; and the lower jaw is provided with barbels. These fishes, of which there are some ten representatives, range from the southern shores of Britain, through the Mediterranean and Atlantic, and likewise from the Indian Ocean to China and the Sandwich Islands. Nowhere abundant, they are believed to inhabit deeper water than the gurnards, which they resemble in their general mode of life.


BEAKED GURNARD ([illegible] nat. size).

Flying Gurnards. Of more interest than either of the preceding are the so-called flying gurnards (*Dactylopterus*) of the Mediterranean, the Tropical Atlantic, and Indo-Pacific Oceans, since they alone share with the true flying-fish the power of taking long flying leaps along the surface of the sea. In order to do this, their pectoral fins are greatly developed, assuming a wing-like form, with the anterior portion shorter and separated from the remainder. The upper surface and sides of the squared, gurnard-like head are bony; long spines are present on the scapular and preopercular; the body is covered with medium-sized keeled scales, among which there is no lateral line; and the second dorsal fin but slightly exceeds the first in length. Although granular teeth are present on the jaw, the palate is toothless. The air bladder is divided into longitudinal halves, and furnished with a muscle. It is only in the adult that the pectoral fins are sufficiently developed to enable these fishes to "fly." Of the three species, the best known is *D. volitans*, which may be commonly met with in the **Mediterranean.** Very similar in their habits to the true flying-fish, the flying gurnards **are more** heavily built and measure as much as 18 inches in length.

Dragon-Fishes.

In this place may be noticed the curious little dragon-fishes (*Pegasus*), from the Indian, Chinese, and Australian seas, which although referred by Dr Günther to a distinct family are included by Day in the present one. In these strange little fishes the broad and depressed body is covered with bony plates, which are movable, although those investing the tail are firmly welded together. The narrow gill-opening is situated in front of the pectoral fin; the gill cover is formed of a single plate, and the gills themselves are four in number. The single short dorsal fin is placed opposite an anal of similar size; the pectorals are long, horizontal, and composed of simple rays, some of which may be spinous; and the pelvis comprises one or two rays, the outer one being elongated. Both teeth and an air-bladder are wanting. The figured species (*P. natans*) is an Australian one, and is less well known than the Indian *P. draco* and the Chinese *P. volans*; dried specimens of the latter being familiar objects on Chinese insect-boxes. Nothing seems to have been ascertained as to the habits of these fish, although it has been suggested that they probably frequent sandy shores. With this family we take leave of the great Cotto-Scombriform section, as it is called, and pass on to another containing only two or three families.

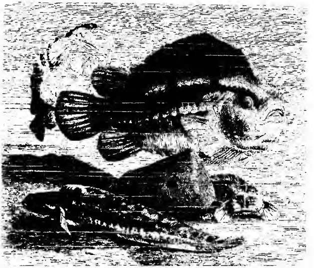


AUSTRALIAN DRAGON-FISH (nat. size).

THE LUMP-SUCKERS,—Family *CYCLOPTERIDÆ.*

With the lump-suckers we come to a small section characterised by the spinous dorsal fin being short, and either composed of flexible spines, or much less developed than the soft dorsal, or soft portion of the same; the soft dorsal being equal in extent to the anal. If present, the pelvic fins are either thoracic or jugular in position, with one spine, and generally five (rarely four) soft rays. There is a prominent papilla in the neighbourhood of the vent. In no case is there a bony stay to the preopercular from the infraorbital ring. As a family, the lump-suckers are characterised by the thick or oblong body, which may be either naked or tuberculated; the small teeth; and the presence of a circular adhesive disc on the lower surface of the chest, surrounded by a fringe of skin, and supported by the rudimental pelvic fins, the gill-opening being narrow. All the members of the family, which are arranged under two genera, are carnivorous and coast-dwelling fishes, restricted to the colder seas of the Northern Hemisphere, and ranging into the Arctic Ocean. They derive their name from their habit of attaching themselves to rocks by means of the adhesive disc.

The members of the typical genus *Cyclopterus* are ugly "lumpy" fishes, with the thick, short body covered with a viscous tuberculated skin; the large head has a very short, blunted muzzle, and there are rows of villiform teeth in the jaws, but none on the palate. The skeleton is remarkable for its softness, owing to the small amount of mineral matter entering into the composition of the bones. In the British species (*C. lumpus*), represented in the upper figure of the accompanying illustration, the skin is so thick as to almost conceal the first dorsal fin, and in the adult the large rough tubercles are arranged in four longitudinal series on each side of the body. In the young, however, these tubercles are not developed. Although these fishes may reach a length of a couple of feet, they do not usually measure more than 12 or 14 inches. Yarrell writes that "in the month of March the colours of the lump-fish are in the highest perfection, combining various



LUMP-SUCKER AND VIVIPAROUS BLENNY (⅓ nat. size).

shades of blue, purple, and rich orange." These voracious fishes feed **chiefly on** the fry of other species. In the Arctic lump-sucker (*C. spinosus*) there **are large,** conical bony plates, surmounted with a spine, on the head and body of **the adult.** In the allied *Liparis* the skin is naked, and more or less loose.

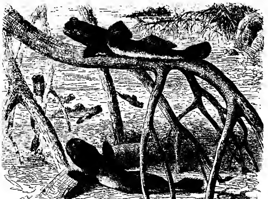
THE GOBIES AND MUD-SKIPPERS,—Family *GOBIIDÆ*.

The gobies and their allies differ from the preceding family in that there are always distinct rays to the pelvic fins; although in some cases the two fins may be joined in the middle line. Elongated in form, the body may be either scaled or naked; and the teeth are generally small, but may have enlarged tusks among them. The spinous portion of the dorsal (whether separate or continuous with the soft dorsal) is always composed of flexible spines, and shorter than the soft dorsal. The gill-opening is more or less narrowed, and there is usually no air-bladder. This very extensive family comprises littoral fishes of small size and carnivorous habits, a few of which have accustomed themselves to a fresh-water life. It contains a large number of genera, some of which are extremely numerous in species as are the latter in individuals; and their range includes the coast-regions of all the temperate and tropical seas. Geologically the group is comparatively ancient, true gobies dating from the middle Eocene of Monte Bolca, while the extinct genus *Chirothrix* occurs in the Chalk of the Lebanon.

FRESH-WATER GOBY (nat. size).

Gobies. Familiar to all in the person of the common British species *Gobius niger*, the gobies form a very large genus, with a geographical distribution as extensive as that of the family, but especially well represented in tropical and subtropical seas, no less than forty different kinds being recorded from those of India alone. These fishes have the body generally scaled; two dorsal fins, of which the first is usually furnished with six flexible spines; the pelvic fins united to form a disc, which, however, is at most only partially adherent to the abdomen; the teeth in more than a single row; and the vertical gill opening of moderate width. The form of the body is subject to considerable specific variation; and in some forms the head, and in others a part or even the whole of the body is devoid of scales. In some cases there may be barbels or warts on the head, and in others a crest on the occiput. There are likewise considerable differences in the dentition, some species having large tusks among the ordinary teeth. The gobies, of which there are several British marine species, are especially partial to rocky coasts, where they protect themselves against waves and storms by adhering to rocks by means of the sucker formed by their modified pelvic fins; many of them being often found in the swirl of the retreating waves. Some, however, prefer brackish estuaries or lagoons, while others again, like the Russian species (*G. fluviatilis*) represented in our illustration, are exclusively fresh-water. In many of them the male constructs a nest in which the spawn is hatched. In the case of the spotted goby, or polewig (*G. minutus*) —a species found for some distance up the Thames—the male, when in tidal pools, generally chooses one of the shells of a cockle or some other bivalve for its nest; the shell being placed on the sand with its concave surface downwards, beneath which the sand is hollowed out and cemented by a special mucilaginous secretion from the skin of the fish; a cylindrical tunnel giving access to the nest, and the whole structure being covered over with loose sand. The female having deposited her eggs, which are fixed to the shell in this nest, the male mounts guard over them, maintaining his watch during the whole period of incubation, which lasts from six to nine days. A European goby (*Latrunculus pellucidus*), belonging to a distinct genus, and characterised by its translucent body, is almost peculiar among vertebrates in that its span of life is of only a year's duration. In June and July the spawn is deposited, the eggs are hatched in August, while in the late autumn or winter the fishes become fully mature; these, however, die off in the following July or August, so that in September only the fry are to be met with.

Mud-Skippers. Omitting all mention of a number of more or less nearly allied genera, our next representatives of the family are the mud-skippers (***Periophthalmus***), remarkable not only for the peculiar physiognomy given them by their conspicuous eyes, but likewise on account of their strange habits. These fishes, which frequent the coasts and estuaries bordering the Indo-Pacific Ocean, and likewise reappear on the shores of West Africa, take their name from their prominent eyes, which are set close together somewhat below the line of the profile, and are not only capable of protrusion and retraction but are furnished with a well-developed outer eyelid. The elongate body is covered with cycloid or slightly pectinated scales, extending on to the bases of the pectoral fins; the cleft of the mouth is nearly horizontal, with the upper jaw projecting somewhat beyond the lower, and the conical teeth are vertical. The first dorsal fin includes a variable number of flexible spines; the base of the pectorals are muscular; the pelvic fins are united for a portion of their length; and the caudal fin has its lower border obliquely truncated. The species here figured (*P. koelreuteri*) has a wide range, being found in the Red Sea, the seas and on the coasts of India, where it ascends tidal rivers and estuaries, as well as in the Andamans, the Malay Archipelago, and the islands of the Pacific. Concerning their habits, Day writes that "these fishes, from the muscular development at the base of the pectoral fins are able to use them for progression on mud or for climbing. It is a most curious sight to see *P. schlosseri* along the side of the Burmese rivers; at a distance the fishes appear like large tadpoles, stationary, contemplating all passing objects, or else snapping at flies or other insects; suddenly, startled by something, away they go with a hop, skip, and a jump, either inland among the trees or on to the water like a flat stone or a piece of slate sent skimming by a schoolboy. They climb on to trees and large pieces of grass, leaves, and sticks, holding on by their pectoral fins exactly as if these were arms. Now and then they plant these firmly as organs of support, the same as one places one's elbows on a table, then they raise their heads and take a deliberate survey of surrounding objects." Of certain allied species which he places in a genus apart, the same writer remarks, that they are essentially mud-dwelling fish, and that if placed in a vessel of deep water they appear to be rapidly drowned. In all, the remarkable prominence of the eyes is more or less completely lost after death. On the slimy banks of the small affluents of the Hughli near Calcutta, where the writer has often watched their strange habits, these fishes may be seen in hundreds.



MUD-SKIPPERS DISPORTING ([illegible] nat. size).—After Hilgendorf

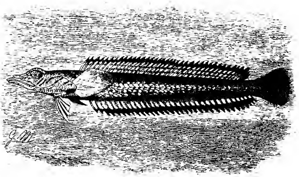
Dragonets. Concerning the precise systematic position of the beautifully coloured fishes commonly known as dragonets (*Callionymus*) there is some difference of opinion; Dr. Günther placing them with the gobies, whereas Day, on account of the wide separation of the pelvic fins (which in the latter and their near allies either form a disc or are very close together), refers them to a separate family. Be this as it may, these fishes, in addition to the feature already mentioned, are characterised by the head and anterior portion of the naked body being depressed, while the remainder is cylindrical. The pointed mouth has a narrow horizontal cleft, and a very protractile upper jaw; the large eyes have a more or less upward direction; small teeth are present on the jaws but none on the palate; and there is a strong spine at the angle of the preopercular. Of the two dorsal fins, the foremost has from three to four flexible spines; the pelvics are five-rayed; and the gill-opening is very narrow, and generally reduced to a perforation on the upper border of the gill-cover. There is a large amount of sexual difference among the dragonets, the adult males having the fin-rays produced into filaments and the intervening membranes brightly coloured, whereas the females wear a much more sombre livery; and it is due to this variation that there were long supposed to be two British representatives of the genus, namely, the gemmeous, and the sordid dragonet; the former being the male and the latter the female. In the adult male of the common dragonet (*C. lyra*) the first dorsal spine is greatly elongated; the general colour of the smooth skin being yellowish, beautifully banded and spotted with lilac; the first dorsal fin bearing several lilac spots, and the second having lilac bands. In length, the male measures about 10 inches. The yellow scalpin, as the male is called in some parts of Britain, is generally found in comparatively deep water, whereas the female often approaches the margin of the tide. Both sexes feed on molluscs and other hard-shelled creatures, as well as on worms. Out of some thirty representatives, the majority are inhabitants of the coast-regions of the temperate zone of the Old World, although a few are found in the Tropical Pacific.

THE BLENNIES AND THEIR ALLIES.—Families *CEPOLIDÆ, BLENNIIDÆ*, etc.

The well-known blennies, together with five less important families, constitute a sectional group of spine-finned fishes, all of which may be treated under one heading. As a group, these fishes are characterised by the body being in general more or less nearly cylindrical in form; the dorsal fin is elongated, and its spinous portion, if distinct, is also long, being equal to or even exceeding the soft part in length, while occasionally the whole fin may be spiny; the anal is also more or less elongate; the pelvics, when present, are thoracic or jugular in position; and the caudal fin, which may be absent, is rounded or somewhat truncated.

Band-Fishes. The first family of the group (*Cepolidæ*) is represented by the small marine band-fishes, of which one species (*Cepola rubescens*) is a casual visitor to the British coasts. The essential characters of these fishes are to be found in the elongate and band-like form of the body; the presence of one spine and five soft rays in the thoracically-placed pelvic fins; and the absence of spines in the single dorsal and anal fins. The eyes are rather large and lateral; the teeth of moderate size, and the caudal vertebræ unusually numerous. While the majority of these fishes are confined to the northern temperate seas, a few extend into the Indian Ocean and as far south as Penang.

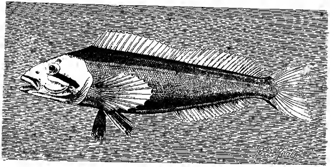
Hairy-Backs The remarkable fishes known as hairy-backs constitute another small family (*Trichonotidæ*) distinguished from the last by the jugular position of the pelvic fins, which are in front of the pectorals; there being one or two spineless dorsal fins, an elongate anal fin, which is also spineless, and no papillæ in the neighbourhood of the vent. The typical genus is represented by a single species (*Trichonotus setiger*) from the Oriental seas, characterised by the first few rays of the single dorsal fin being isolated and more or less elongate, and likewise by the lower jaw exceeding the upper in length. The New Zealand thorny-nose (*Hemerocoetes acanthorhynchus*) represents a second genus, differing from the last by all the rays of the long dorsal being in juxtaposition, by the upper jaw being longer than the lower, and the presence of horny processes on the muzzle. These fishes are not unfrequently found floating on the surface of the ocean at a considerable distance from land.



NEW ZEALAND THORNY-NOSE.

Chirus The most remarkable representatives of a third small family (*Chiridæ*) of this group constitute the genus *Chirus*, which is peculiar in having several lateral lines, the number of these varying in the different species. The family differs from the two preceding ones in that there is a bony stay connecting the preopercular with the infraorbital ring, while it is further distinguished by the single dorsal having its spinous and soft portions of nearly equal length, the anal being nearly equal in length to the soft dorsal, and the pelvics thoracic in position, with one spine and five rays. The compressed and oblong body is scaled, the cleft of the mouth lateral, and the teeth are weak. All the members of the family are small littoral fishes, inhabiting both sides of the Northern Pacific; the figured species (*Chirus hexagrammus*) being from Japanese waters. In the other genera the lateral line is single.

Blennies. The fourth family of the group (*Blenniidæ*) is much more extensive than either of the others, comprising a considerable number of genera, some of which are rich in species. The family agrees with the hairy-backs in the jugular position of the pelvic fins, which, when present at all, are composed of a very few soft rays. In the anal fin, the spines are few or wanting, and there is very generally a papilla in the neighbourhood of the vent. The low and clongate body is more or less cylindrical in form, and either naked or covered with scales, which are generally of small size. The dorsal fin, which may be either single, double, or triple, occupies nearly the whole length of the back; and when it has a distinct spinous portion, this is at least as much developed as the soft part, while in some instances the whole fin may be spiny; the anal being elongate. In most cases false gills are present. All the marine members of the family are littoral forms, and the majority are of small size, while some are among the smallest of all fishes. They are abundant throughout all tropical and temperate seas; and whereas some forms inhabit brackish water, others are exclusively freshwater. Dr. Günther writes that "one of the principal characteristics of the blennies is the ventral [pelvic] fin, which is formed by less than five rays, and has a jugular position. The blennies have this in common with many gadoids [cod tribe], and it is sometimes difficult to decide to which of these two families a fish should be referred. In such doubtful cases the presence of the pseudobranchiæ (which are absent in gadoids) may be of assistance. In many blennies the ventral fins have ceased to have any function, and become rudimentary, or even entirely absent. In others, the ventral fins, although reduced to cylindrical stylets, possess a distinct function, and are used as organs of locomotion, by the aid of which the fish moves over the bottom." The family is not definitely known in a fossil state although it may be represented by an extinct genus in the Monte Bolca Eocene



JAPANESE CHIRUS.

The blennies of the typical genus *Blennius*, of which there are some forty species, are found in the northern seas, the Tropical Atlantic, the coasts of Tasmania, and the Red Sea. They are characterised by the moderate elongation of the naked body, the short snout, the single continuous dorsal fin, and the presence of one spine and two rays in the pelvics. The cleft of the mouth is narrow, the jaws contain a single series of fixed teeth, behind which there is generally one larger curved tooth, at least in the lower jaw. Above each eye is the longer or shorter tentacle, and the gill-opening is relatively wide. Among British species we have the eyed blenny (*B. ocellatus*) distinguished by the dark spot on the elevated spinous portion of the dorsal, the smooth blenny or shanny *B. pholis*, and the large *B. gattorugine*, which may grow to a foot in length; while as an example of a species living in inland lakes we may cite the fresh-water blenny (*B. vulgaris*) of Southern Europe. Most can be readily accustomed to a fresh-water life, and many of the marine species attach themselves to floating objects, while some are found far out at sea among the patches of drifted seaweed. In the Indian seas the blennies are represented by seven more or less closely allied genera, in one of which (*Xiphasia*) the body is band-like, and the caudal fin continuous with the dorsal and anal.

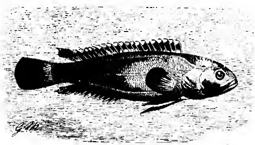
Viviparous Blennies The fish (*Zoarces viviparus*) of which two examples are represented in the lower part of the illustration on p. 387, is one of two species of a genus remarkable for producing living young. With an elongate body, rudimental scales, and conical teeth in the jaws, these fish have an extremely elongated dorsal fin, separated from the caudal merely by a depression formed by a series of spines much shorter than the rays; these spines being the only ones throughout the fins. The pelvic fins are composed of three or four rays; and the long anal fin is continuous posteriorly with the caudal. The gill-openings are wide. While the figured European species, which is not uncommon on the British coasts, does not exceed a foot in length, its Transatlantic cousin (*Z. anguillaris*) may measure two or three times as much. The fry, which at birth are perfectly transparent, and form beautiful objects for the microscope, are so fully developed as to be able at once to swim freely on leaving the body of the female parent. Before their birth the female becomes so distended, that at the slightest pressure the young are extruded; these frequently being from two to three hundred in number and always making their appearance in the world head first. The general colour of the adult fish is pale brown, with the dorsal fin and upper-parts mottled and barred with darker brown.

Wolf Fishes Easily recognised by the powerful tuberculated and molar-like teeth with which their mouths are armed, the wolf-fishes (*Anarrhichas*) may be regarded merely as gigantic and somewhat specialised blennies. In this genus, which is represented by a small number of species from the northern seas of both the Eastern and Western Hemispheres, the elongate body is covered with rudimental scales; the muzzle is rather short and the cleft of the mouth wide; and the jaws are armed with strong conical teeth, those of the lateral series carrying several pointed cusps, while a double row of large molar-like teeth runs down the middle of the palate. The long dorsal fin has flexible spines, and there is a distinct caudal, but the pelvic pair are quite wanting. The gill-opening is wide.

The common wolf-fish (*A. lupus*), often known as the sea wolf or sea cat, like two allied species, ranges as far north as Norway and Greenland, in both of which countries its flesh forms a staple article of food.

Oblique-Spined Blenny.

The fifth family (*Acanthoclinidæ*) of the section under consideration is represented only by the New Zealand oblique-spined blenny (*Acanthoclinus littoreus*), shown in the annexed illustration, and is characterised by the elongate, low, compressed, and scaly body, the single dorsal fin—chiefly composed of spines—occupying nearly the whole length of the back, and the comparatively long and many-spined anal, the pelvic fins being jugular in position, and consisting solely of a few soft rays. On the coasts of New Zealand this blenny is stated to be a very common fish; its habits being probably similar to those of its European cousins.



OBLIQUE-SPINED BLENNY (nat. size).

Spiny Eels.

The so-called spiny eels of the Oriental region and West Africa form a family (*Rhynchobdellidæ*) affording an interesting example of parallelism in development, since these spiny-finned eels are an exact analogue of the true soft-finned eels. They are characterised by the elongate eel-like form of the body; the long dorsal fin, of which the anterior portion consists of short isolated spines; and the absence both of pelvic fins and of a papilla in the neighbourhood of the vent. The gill-opening forms a slit on the side of the head; four gills are contained in the gill-chamber, and there are no false gills. An elongated movable appendage forms the termination of the muzzle, and although the lower jaw is long, it has but little power of motion. As an especial peculiarity of these fishes, we may notice that in the skeleton there is no connection between the pectoral girdle and the skull. The air-bladder is present. The species (*Mastacembelus armatus*), shown in the upper figure of the illustration on p. 396, is one of the Indian representatives of a genus characterised by the smooth under surface of the appendage of the snout, and the presence of a preorbital spine. The members of this genus have a geographical distribution coextensive with that of the family, being found in the brackish and fresh waters of West Africa, India, Ceylon, Burma, and the Malayan region. On the other hand, the genus *Rhynchobdella*, characterised by the striation of the lower surface of the nasal appendage, and the lack of a spine in front of the eye, is confined to India and Burma, where it is represented by *R. aculeata*, which grows to a length of about 15 inches, and is found in the deltas of all the larger rivers, generally preferring muddy pools. The figured species is, however, of larger size, reaching a couple of feet in length. The flesh of all the spiny eels is stated to be of excellent quality for the table.

Oil Fish.

The fish represented in the lower portion of the annexed illustration, known as the Baikal oil-fish (*Comephorus baikalensis*), is the only representative of a genus in regard to the systematic position of which there is considerable doubt, Dr. Günther regarding it as indicating a distinct family which he at one time placed in the neighbourhood of the oblique-spined blenny, and afterwards near the flying gurnards. In this fish the body is elongate and naked, the head large with a produced muzzle, medium-sized lateral eyes, and small teeth. There are two dorsal fins, of which the first is much shorter than the second, which is similar to the anal; the pelvic fins are wanting, and there is no papilla near the vent. The gill-opening is wide; there are four gills and no air-bladder. The skeleton is very soft; and the elements of the gill-cover are not distinctly differentiated. In colour this strange fish is uniformly greenish, and its pectoral fins are remarkable for their large size. While the oil-fish presents some resemblance to the dragonets, it differs by the compressed body, the large, broad-snouted head, the elongation of many of the rays of the second dorsal fin, the large pectorals, the absence of pelvic fins, and the forked tail. So far as present information goes, the oil-fish is confined to Lake Baikal, where in winter it retires to the greatest depths, but approaches

INDIAN SPINY EEL (¼ nat. size). BAIKAL OIL-FISH (½ nat. size).

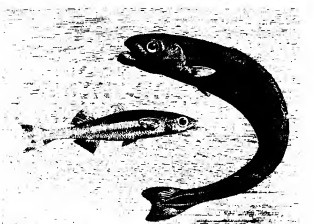
the shore in the warmer months. Swimming with remarkable speed, it is enabled by the length of its pectorals to take considerable leaps above the surface of the water, and thus approaches the flying-fish. During stormy weather great numbers of these fishes are frequently stranded, when they are collected by the natives for the purpose of extracting the oil from them.

BARRACUDAS, ATHERINES, AND GREY MULLETS.—Families *SPHYRÆNIDÆ*, *ATHERINIDÆ*, and *MUGILIDÆ*.

Following Dr Günther's classification, these three families form a sectional group differing from those we have been considering by the position of the pelvic fins, which are abdominal, and have one spine and five soft rays. The two dorsal fins are situated more or less remote from one another, the first being either short, like the second, or composed of weak spines.

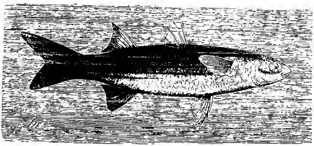
Barracudas. The large and ferocious fishes commonly known as barracudas (*Sphyræna*), of which a species (*S. vulgaris*) is shown in the upper figure of the illustration on p. 379, are the sole existing representatives of the first family, which is distinguished by the elongated and subcylindrical form of the body, the large cutting-teeth, the continuous lateral line, and the presence of only twenty-four vertebræ in the backbone. The scales are small and cycloidal; the cleft of the mouth is wide; and the medium-sized eyes have a lateral position. Represented by something less than a score of species, barracudas are distributed over all temperate and tropical seas, but generally prefer the neighbourhood of the coast to the open ocean. They are all carnivorous and fierce in their disposition, and since they frequently grow to 6 or 8 feet in length, they are as much or even more dreaded by bathers in seas where they are common than sharks. They are extensively caught for food, but in some instances, from their having fed on poisonous kinds of fish their own flesh becomes impregnated with the venom. Moseley writes that "there is a great fishery at the Cape, of a fish called snook, a kind of barracuda, which is salted and dried, and sent mainly to Mauritius for sale. The snook-boats were always to be seen about in the bay. The fish are caught with a hook and line whilst the boat is in motion. The fishermen are especially careful not to get bitten by the fish as they haul them in, wounds caused by their bite being said to fester in a violent manner, as if inflamed." Fossil barracudas occur in the middle Eocene of Monte Bolca; while in the Cretaceous rocks of the Lebanon and Brazil the family is represented by the extinct genus *Cladocyclus*.

Sand-Smelts. The second family of the group under consideration is typically represented by the so-called sand-smelts, one of the two British species (*Atherina hepsetus*) being shown in the left figure of our illustration. As a family, the *Atherinidæ* are distinguished from the barracudas by the indistinct lateral line; the feeble or moderately developed dentition; and by the number of vertebræ being usually in excess of twenty-four. The body is more or less elongate, with but slight compression. In the sand-smelts the scales are smooth and cycloid, and the teeth minute; the first dorsal fin is short and completely separate from the second; and the muzzle is blunt, with the cleft of the mouth straight, oblique, and extending at least as far back as the line of the border of the eye. These fish derive their popular title from their resemblance to the true smelts, from which they may be distinguished at a glance by the small spinous first dorsal fin. While the majority are coast fishes, associating in large shoals, others are fresh-water, although these also retain the same habit. The genus has a wide distribution in temperate and tropical seas, some of the species ranging from Eastern Africa to India. Atherines are very abundant in the Mediterranean, where the fry cling together for some time after hatching in enormous masses. Montagu writes that these fish are caught in great abundance on the south coast of Devonshire "in the creeks and estuaries, but never in rivers above the flow of the tide; and they appear to continue near shore through the months from autumn to spring, being caught for the table more or less during the whole of that time, but are greatly superior in spring, when the males are full of milt as the females are of roe." The British species seldom exceed 6 inches in length, and, like the other members of the genus, are marked by a broad silvery stripe along each side of the body. On the coasts and in the fresh waters of Australia the sand-smelts are represented by *Atherinichthys*, in which the muzzle is longer, and the cleft of the mouth usually shorter.


SAND-SMELT AND CUVIER'S SQUARE-TAIL (½ nat. size).

Square Tail. The curious Mediterranean and Atlantic fish known as Cuvier's square-tail (*Tetragonurus cuvieri*), shown on the right side of our illustration, is the sole member of a genus characterised by the somewhat elongate body being covered with strongly keeled and striated scales; and by the first dorsal fin being composed of a number of short spines, and continuing to the second. The elevated lower jaw has a convex upper border, bearing a single series of rather small compressed and triangular teeth. Of the habits of this scarce fish nothing definite seems to be known, although in the young state it is found in company with floating jelly-fish. At a later period of its existence it probably descends to a considerable depth during the day, and comes to the surface only at night. It grows to a foot and a half in length.

Grey Mullets. From the two preceding families the grey mullets, which constitute the third family of the group under consideration, may be distinguished by the total absence of a lateral line, the presence of only four stiff spines in the first dorsal fin, and the limitation of the number of vertebræ in the skeleton to twenty-four. The more or less elongate and somewhat compressed body is covered with cycloid or slightly ctenoid scales of moderate size; the cleft of the mouth is small or medium: the teeth are feeble or wanting; the lateral eye is of moderate size; and the gill-opening wide. In some species there may be a fatty lid to the eye. The grey mullets (*Mugil*), of which there is a very large number of species, are distributed over all temperate and tropical coast-regions, frequenting brackish-water estuaries, and in some cases ascending rivers for considerable distances. Feeding chiefly upon the animals and organic matter found in sand and mud, these fishes have a special straining apparatus in the pharynx for the purpose of preventing objects of too large size from entering the stomach, or foreign substances getting into the gill-chamber. It will be unnecessary to describe the structure of this apparatus here; but it may be mentioned that after triturating a mouthful of sand or mud between the pharyngeal bones, in order to extract such nutriment as it may contain, the grey mullets reject the mineral part of it. Another peculiarity is to be found in the structure of the œsophagus and stomach, the former being lined with long thread-like papillæ, while the latter has its second portion furnished with muscular walls like the gizzard of a bird, although it is not divided into two lateral halves.



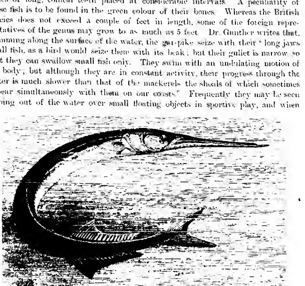
COMMON GREY MULLET (⅓ nat. size)

A fossil species of grey mullet has been described from the upper Eocene of Provence, and an extinct genus from the Cretaceous. Our figure represents the common grey mullet (*M. capito*), one of several species frequenting the British coasts. Although this mullet only grows to a weight of about 4 lbs., some of the foreign species may scale three times as much. This mullet has been kept in a fresh-water pond, where it seemed to thrive better than in the sea. The flesh of all the grey mullets is of good quality, but bears no comparison to that of their red namesakes.

GAR-PIKE AND FLYING FISH.—Family *SCOMBERESOCIDÆ*.

In this place may be noticed a family in regard to the serial position of which there is some difference of opinion, Dr. Günther placing it among the tube-bladdered fishes, while Professor Cope considers that its true position is here. The inclusion of the group among the tube-bladdered fishes utterly spoils the definition of that suborder, since in those members of the present family provided with an air-bladder that organ lacks a duct. It is true that the fins of the flying-fishes and their allies are less spiny than those of the more typical representatives of the suborder under consideration, but, as we have seen, this character is one of but slight morphological value. Agreeing with the preceding section in the abdominal position of the pelvic fins, these fishes differ from those yet described with the exception of certain perches in the union of the lower pharyngeal bones; while they are further characterised by the absence of a spinal dorsal fin, and the deeply forked caudal. The single dorsal is situated opposite to the anal fin in the caudal region, the air-bladder is generally present, the false gills are hidden and glandular, and the simple stomach merely forms a dilatation of the intestinal tract. Although the majority of the members of this family are marine, some being pelagic, a few have taken to a fresh-water existence; and while many of the latter are viviparous, the whole of the others deposit eggs in the usual manner. Distributed over all the temperate and tropical seas, these fish are strictly carnivorous in their habits. Geologically, the family is a comparatively ancient one, the gar-pike being represented by an extinct species in the Sicilian Miocene, and by an allied extinct genus in the Eocene of Monte Bolca, while a fish nearly allied to the living flying-fishes occurs in the Cretaceous rocks of the Lebanon.

Gar-Pike. In North America it appears that the name "gar-pike" is applied indifferently to a member of the present family, and to the very distinct fish also known as the bony pike; but in scientific nomenclature it will be better to confine the term to the members of the present genus. Gar-pike are represented by nearly fifty species from temperate and tropical seas, among which the figured one (*Belone vulgaris*) is common on the British coasts, likewise ranging over the whole of the seas of Northern Europe. As a genus, these fishes are easily recognised by the production of the jaws into a long slender beak, formed in the upper one exclusively by the premaxillary bones; while they are further characterised by the whole of the rays of the dorsal and anal fins being connected by membrane. The beak is, however, only developed in the adult, very young specimens having the jaws of normal form; and it is not a little remarkable that during their development the lower jaw becomes for a time much longer than the upper one. Both jaws are beset with a number of rugosities, and likewise with a series of long, conical teeth placed at considerable intervals. A peculiarity of these fish is to be found in the green colour of their bones. Whereas the British species does not exceed a couple of feet in length, some of the foreign representatives of the genus may grow to as much as 5 feet. Dr Gunther writes that, skimming along the surface of the water, the gar-pike seize with their "long jaws small fish, as a bird would seize them with its beak; but their gullet is narrow, so that they can swallow small fish only. They swim with an undulating motion of the body; but although they are in constant activity, their progress through the water is much slower than that of the mackerels the shoals of which sometimes appear simultaneously with them on our coasts." Frequently they may be seen leaping out of the water over small floating objects in sportive play, and when



GAR-PIKE (⅓ nat. size).

struck by the hook throw themselves above the surface in violent contortions. The saury, or skipper (*Scombresox saurus*), is the British representative of a much smaller genus, differing from the gar-pikes by the minute size of the teeth, and likewise by the presence of a number of small finlets behind the dorsal and anal fins. On the other hand, the half-beaks (*Hemirhamphus*), some of which inhabit fresh water, have the lower jaw larger than the upper throughout life.

Flying-Fish. Perhaps few sights are more pleasing during a long sea-voyage in an ocean steamer than to stand in the bows and to watch the flying-fish rising—sometimes singly, but more frequently in larger or smaller shoals—from beneath the vessel to take their beautiful flight over the crest of the waves, till they once more disappear from view beneath the deep blue waters. Represented by more than forty species from tropical and subtropical seas, the flying-fishes, of which the common species (*Exocoetus volitans*) is shown in the illustration on p. 314, form a genus which may be at once recognised by the great length of the pectoral fins. They are further characterised by the blunt and short-jawed head, and the moderately long oblong body invested in a coat of rather large-sized scales; the teeth, when present at all, being minute or rudimental. The ordinary length of a flying-fish is from 10 inches to a foot, although specimens are occasionally met with half as long again; and whereas the common form ranges round the world, the distribution of some other species is extremely restricted, one being recorded only from the seas on the Pacific side of the Isthmus of Panama. The species differ considerably in the length of the pectoral fins; those in which they reach to the tail-fin being capable of taking the longest flights, whereas in some others they do not extend beyond the anal. Associating in shoals, which are sometimes of immense size, all these fish are pelagic in their habits, and all are capable of taking the skimming flight from which they derive their name. That these fish take their flights primarily to escape from their enemies may be regarded as certain; and it is equally well ascertained that the continuance of the flight is due to the original impetus of the leap from the water, and is not prolonged by any flapping of the fins. From my own observations I am, however, of opinion that the pectoral fins are vibrated rapidly on first leaving the water for a few seconds, doubtless from a continuation of the swimming motion while in the water, after which they become entirely motionless. During flight the colour of these fins may appear either white or brown, when seen from above, according to the incidence of the light. So far as I have seen, flying-fish are unable to change the direction of their course to any marked extent; but on this point, as will be seen from the two following accounts, there is some difference of opinion among observers. The first of these two accounts is abridged by Dr. Günther from one published by Dr. Möbius, and runs as follows: "Flying-fish are more frequently observed in rough weather and in a disturbed sea than during calms; they dart out of the water when pursued by their enemies, or frightened by an approaching vessel, but frequently also without any apparent cause, as is also observed in many other fishes; and they rise without any regard to the direction of the wind or waves. The fins are kept quietly distended, without any motion, except an occasional vibration caused by the air whenever the surface of the wing is parallel with the course of the wind. Their flight is rapid, but gradually decreasing in velocity, greatly exceeding that of a ship going ten miles an hour, and extending to a distance of five hundred feet. Generally, it is longer when the fish fly against than with, or at angle to the wind. Any vertical or horizontal deviation from a straight line is not caused at the will of the fish, but by currents of the air; the fish retaining a horizontally straight course when flying with or against the wind, but being carried to one side whenever the direction of the latter is at an angle to that of their flight. It may, however, happen that in the course of its flight a fish may dip its tail in the crest of a wave, thus changing its direction to the left or right. In calm weather the line of flight is always also vertically straight, or rather parabolic like the course of a projectile, but in a rough sea, when the fish are flying against the course of the waves, it may become undulating. In such instances the flying-fish frequently overtop each wave, being carried over by the pressure of the disturbed air. Flying-fish often fall on board vessels, but this never happens during a calm, or from the lee-side, always taking place in a breeze and from the weather-side. In the daytime they avoid a ship, flying away from it; but, during the night, when they are unable to see, they frequently fly against the weather-board, where they are caught by the current of air, and may be thus carried to a height of some twenty feet above the surface of the water." In the second account, which was published many years ago in *Land and Water*, the author writes that in calm weather flying-fish "are capable of clearing three hundred yards. Their flight is frequently extended to double the distance by simply skimming the surface as a swallow does a pool, and without disappearing. I have observed that they never touch the surface more than twice consecutively, though they may resume their flight after a period of complete immersion; while still in the air, they readily change their course to right angles with their first line of flight, or even completely reverse it towards the point from which they originally started. I have watched them for hours through a powerful double glass, as they rose from either side of the bows of the ship, and noticed that the pectoral fins are moved with a slight but very rapid quivering motion, which, I have no doubt, assists to sustain them in the air. In rough weather the flight of the flying-fish is more rapid, much higher, and of shorter duration than when light winds prevail." This account confirms my own observations as to there being a vibratory motion of the pectoral fins when first leaving the water, although the writer is probably incorrect in his supposition that this assists the flight.

STICKLEBACKS, FLUTE-MOUTHS, AND TRUMPET-FISH.—Families *GASTROSTEIDÆ*, *AULOSTOMATIDÆ*, and *CENTRISCIDÆ*.

Although the third of the above-named families is regarded by Dr. Günther as forming a group apart, we may follow Day in placing the whole three in a single section, characterised by the spinous dorsal fin, when present, being either short or formed of isolated spines, and by the generally abdominal position of the pelvic fins, which in some instances are imperfectly developed.

Sticklebacks

Familiar to every home-born Englishman as the fish upon which, in common with minnows, he made his first experiment in angling with the aid of a bit of twine, a bent pin, and a worm, the sticklebacks have the honour not only of representing a genus (*Gastrosteus*), but likewise a family by themselves. Taking their name from the presence of a variable number of isolated spines in advance of the soft dorsal fin, sticklebacks have the body more or less elongate and compressed, the cleft of the mouth oblique, and the teeth villiform. The gill-cover is unarmed, and the cheek covered by the infraorbital bone; and in place of scales there are generally large plates along the sides of the body. The pelvic fins, although abdominal in position, are connected with the pectoral girdle by means of the pelvic bones, and consist of but one spine and a single ray; and there are but three branchiostegal rays. Confined to the Temperate and Arctic zones of the Northern Hemisphere, where they are represented by some half-score species of small bodily size, sticklebacks are mainly fresh-water fishes, although the sea-stickleback (*G. spinachia*) is a marine or brackish-water form, and all the rest can live as well in salt as in fresh-water. The British fresh-water representatives of the genus are distinguished by the number of the dorsal spines, and are known as the three-spined (*G. aculeatus*), four-spined (*G. spinulosus*), and nine-spined sticklebacks (*G. pungitius*); while in the United States *G. noveboracensis* is the most familiar kind. The three-spined stickleback is a singularly variable species, the plates which are present on the sides of the body in some specimens, being wanting in others; the unprotected condition being especially common in the race from Central Europe. Very different in appearance from the others is the fifteen-spined, or sea stickleback, in which the body is very long and thin; this species ranging as far north as Norway and the Baltic. It has recently been ascertained that all the individuals of this stickleback die within a year of their birth; so that we have here a second example of an annual vertebrate, the first being the one mentioned on p. 389.

GROUP OF STICKLEBACKS.

Sea-stickleback (upper figure); Nine-spined stickleback (middle figure); and Three-spined stickleback (lower figure), (nat. size).

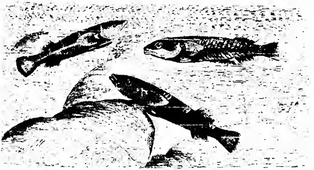
Sticklebacks are extremely pugnacious, and at the same time highly voracious fishes, the males engaging in fierce conflicts with one another; while both sexes consume a vast quantity of the fry of other fish, and are, therefore, most objectionable denizens of preserved waters. It is not, indeed, that a single stickleback can do a very great deal of harm, but the mischief results from the enormous numbers of these little marauders. As an instance of this, we may once more quote the well-known statement of Pennant, that a man employed by a Lincolnshire farmer to rid a stream of sticklebacks for a considerable time made four shillings a day by selling his catch at the rate of a halfpenny per bushel. In fighting, the males make full use of the formidable spines on the back, with which they have been seen to rip open the body of an antagonist. The most interesting trait in the economy of sticklebacks is, however, undoubtedly the nest-building habit of many of the species. In the sea-stickleback the nest is composed of a mass of pendent seaweeds, bound together by a silk-like thread into a pear-shaped form, in the centre of which are deposited the eggs. Such a nest has been known to be guarded for a period of upwards of three weeks by the male parent fish; and when it sustained any damage, by which the eggs were exposed to view, the watchful guardian set about repairing the mischief with the greatest despatch and energy, thrusting its nose deep into the structure, and pushing and pulling the materials till all was once more sound. The following account of the nesting of the three-spined stickleback in an aquarium was forwarded by a correspondent to Frank Buckland. On this occasion the male 'selected a spot nearly in the centre of the trough, and busily set to work to make a collection of delicate fibrous materials, placed on the ground, and matted into an irregularly circular mass, somewhat depressed, and upwards of an inch in diameter, the top being covered with similar materials, and having in the centre a rather large hole. His work was commenced at noonday, and was completed, and the eggs deposited by half-past six in the afternoon. Nothing could exceed the attention from this time evinced by the male fish. He kept constant watch over the nest, every now and then shaking up the materials and dragging out the eggs, and then pushing them into their receptacle again, and tucking them up with his snout, arranging the whole to his mind, and again and again adjusting it till he was satisfied; after which he hung or hovered over the surface of the nest, his head close to the orifice, the body inclined upwards at an angle of about 45°, fanning it with the pectoral fins, aided by a side-motion of the tail. This curious manœuvre was apparently for the purpose of ventilating the spawn; at least by this means a current of water was made to set in towards the nest, as was evident by the agitation of particles of matter attached to it. This fanning or ventilation was frequently repeated every day till the young were hatched, and sometimes the fish would dive head foremost into his nursery and bring out a mouthful of sand, which he would carry for some distance and discharge with a puff. At the end of a month the young ones were first perceived. The nest was built on the 23rd of April, the young appeared first on May 21. Unremitting as had been the attention of this exemplary parent up to the time of the hatching of the eggs, he now redoubled his assiduity. He never left the spot either by day or night; and during the daytime he guarded it most pertinaciously, allowing nothing to approach. . . . The fry were at first so minute and transparent that they were scarcely perceptible, and it was only by a slight fluttering motion their position could be occasionally discovered; otherwise it was impossible to detect them.'

Flute Mouths. Although the name of pipe-fishes is frequently applied to the members of the second family of the group under consideration, it is better to restrict that term to the *Syngnathidæ* (described in the sequel), and take that of flute-mouths for those to be now noticed. As a family, the flute-mouths are readily distinguished from the sticklebacks by the production of the bones of the muzzle into a long tube, terminated by a small mouth; and likewise by the pelvic fins consisting of six soft rays. The greatly elongated body is either covered with very small scales or naked; the teeth are small; the first dorsal, if present, is formed of small isolated spines; the soft dorsal and anal are of moderate length; the pelvic fins consist of six rays, without any spine, and are separated from the pubic bones, which remain attached to the pectoral arch; and there are five branchiostegal rays. The air-bladder is large, and the vertebræ are very numerous, those in the anterior part of the column being fused into a continuous tube, as in the flying gurnards. These fishes, which may be regarded as gigantic and highly specialised marine sticklebacks, frequent the coasts of the tropical and subtropical portions of the Atlantic, Indian, and Pacific Oceans, some of them growing to from 4 to 6 feet in length. In the genus *Fistularia*, the body is naked, the forked caudal fin has one or two of its middle rays produced into a long whip-like filament, and there are no isolated spines to the dorsal fin. The species are confined to the Tropical Atlantic and Indian Oceans. On the other hand, in the typical genus *Aulostoma* the body is covered with small scales, the caudal fin squared, and without filaments, while the back carries a series of small isolated spines, and the teeth are rudimentary. In this genus the species inhabit the Atlantic; but the third genus (*Auliscops*) is represented by a single form from the North American Pacific coast, distinguished by the naked body, the thoracic position of the pelvic fins, and the presence of numerous spines in front of the dorsal fin. Day states that he found the Indian species of *Fistularia*, which is common at Madras, frequenting the most muddy localities.

Trumpet Fishes, etc. While agreeing with the flute-mouths in the production of the muzzle into a tubular beak, the two genera of fishes constituting the family *Centriscidæ* differ by the imperfect development of the pelvic fins, which are truly abdominal in position. They have two dorsal fins, of which the spinous one is short, while the soft one is similar to the anal. Teeth are wanting. The family is distributed over the Atlantic, Mediterranean, and Indo-Pacific, the common trumpet or bellows fish (*Centriscus scolopax*) occasionally making its appearance on the south coast of England, while it is also known from such a distant region as Tasmania. It belongs to a genus characterised by the oblong or elevated and compressed body being covered by small rough scales, with some bony strips on the back and under surface, the absence of a lateral line, and the length of the spines of the first dorsal fin. The second genus, *Amphisile*, differs by the elongate form of the compressed body, which is covered on the back with a cuirass of bony plates, behind which are the two dorsal fins. This genus is confined to the Indo-Pacific, and in the Indian *A. scutata* the dorsal armour terminates behind in a long spine, close beneath which are the three spines of the first dorsal fin, followed by the second dorsal, the caudal appearing on the lower surface of the body just behind the anal. Dr. Günther writes that in these tortoise-fishes, as they may be called, the "body is so thin that it has the appearance of being artificially compressed between two sheets of paper; it is semi-transparent, especially in the region of the air-bladder. The structure of the vertebral column is extremely singular, and unique among Acanthopterygians. The trunk portion is more than four times as long as the caudal, nevertheless it is composed of only six vertebræ, whilst the latter consists of fourteen." The trunk vertebræ are extremely slender, the third alone being nearly as long as the whole caudal portion; while in the latter all the vertebræ are very short. In a fossil state the tortoise-fishes are represented in the middle Eocene of Monte Bolca; and it may be mentioned here that in the preceding family the genera *Fistularia* and *Aulostoma* occur not only in those deposits, but likewise in the lower Eocene of Switzerland; and *Auliscops* has been recorded from the Eocene of Sumatra, and two extinct generic types have been described from the Monte Bolca beds.

THE SUCKER-FISHES,—Family *GOBIESOCIDÆ*

The small fish (*Lepadogaster bimaculatus*), of which three examples are shown in the annexed illustration, is one of three British representatives of a genus belonging to a small family which constitutes a sectional group by itself. Long confounded with the lump-suckers, which they resemble in having an adhesive disc on the under surface of the body, the sucker-fish differ from that group, not only in the structure of that disc, but likewise in several other respects. They have no spinous dorsal fin; the soft dorsal and anal are short or of medium length and situated far back, at the root of the tail; the pelvic fins are almost jugal in position, and have the adhesive disc placed between them; while the body is covered with a naked skin. Whereas in the lump-suckers the pelvic fins are close together, and actually form the base of the sucking disc, in the present family they are widely separated from each other, and only enter into the composition of a portion of the margin of the adhesive apparatus, which is completed by a cartilaginous expansion of the bones of the pectoral girdle. In size the ovoid disc is relatively large, its length being sometimes as much as one-third that of the whole fish, and it is divided into an anterior and a posterior moiety, of which the second may or may not have a free front margin. All these fishes are littoral forms of small size, ranging over both temperate zones, where they are more



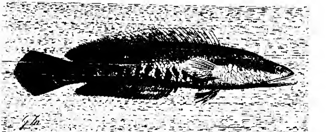
TWO-SPOTTED SUCKER-FISH (NAT. SIZE).

numerous than in the tropics. Among the numerous genera we can only mention the typical *Gobiesox*, from the West Indies and Pacific coast of South America, distinguished by the absence of a front free margin to the posterior division of the sucker, and the presence of incisor-like teeth at least in the lower jaw; and the European *Lepadogaster*, in which the hinder-half of the sucker has an anterior free margin, and the teeth are small and fine. The British species, although variable in this respect, are very prettily coloured; the figured one being generally carmine-red above, and pale flesh-colour below, with a light patch between the eyes, and two more or less distinct spots on the sides. It has been obtained adhering to stones and shells in deep water off Torquay. Montagu writes that when placed in a vessel of sea-water these little fish "always adhered to the sides of the glass by the apparatus termed the sucker, and frequently remain fixed till they died; and even after death the power of adhesion continues. The wet finger being applied to the part, the fish becomes suspended; when alive, they instantly attach themselves to the hand if taken out of the water."

THE SERPENT-HEADS.—Family *OPHIOCEPHALIDÆ*.

Mainly characteristic of the Oriental region, although also represented in Africa, the fresh-water fishes known as serpent-heads are interesting not only on account of their structure, but likewise from their peculiar habits. They form a single family, constituting a sectional group by itself, and represented by two genera, in one of which (*Ophiocephalus*) pelvic fins are present, while in the second (*Channa*) they are wanting. As a family, the serpent-heads are characterised as follows. The body is elongate and covered with medium-sized scales; all the fins are devoid of spines, the anal and single dorsal being long and low; and there is an additional cavity above the proper gill-chamber, although this is not furnished with supplemental gills. The depressed head is covered with somewhat plate-like scales, and has the eyes lateral and the gill-openings wide; each gill-chamber containing four gills, while teeth are present on the jaws, palatines, and vomer. If present, the pelvic fins are thoracic in position, and composed of six rays. The lateral line is sharply curved or almost interrupted, and an air-bladder is present. Of the typical genus there are some thirty existing species, having a distribution coextensive with that of the family, and in Asia ranging over Baluchistan, Afghanistan, India, Ceylon, Burma, China, Siam, and the Malay Archipelago; the figured species (*O. striatus*) being common to such distant localities as India and the Philippines, and at times reaching as much as a yard in length. The second genus, *Channa*, is represented only by a single species from Ceylon and China. In a fossil state these fishes have been identified from the Pliocene rocks of the Siwalik Hills in North-Eastern India.

In India the serpent-heads are found both in rivers, ponds, tanks, and swamps, many of them seeming to prefer stagnant to running waters. Day writes that these fishes "having hollow cavities in their heads, and an amphibious mode of respiration, are able to exist for lengthened periods out of their native element, and can travel some distance over the ground, especially when it is moist. They are able to progress in a serpentine manner, chiefly by means of their pectoral and caudal fins, first one of the former being advanced and then the other. These fishes appear to be monogamous, some breeding in grassy swamps or the edges of tanks, some in wells or stone-margined receptacles for water, and others again in holes in river-banks. The varieties which live in tanks and swamps keep much to the shallow and grassy edges. Amongst the fish which I myself saw exhumed from the mud of a dried-up tank were some *Ophiocephali*; they are also recorded by the natives of India as descending with downpours of rain." When living in muddy water they rise to the surface from time to time to take in atmospheric air, and captive examples prevented from doing this have been known to die.



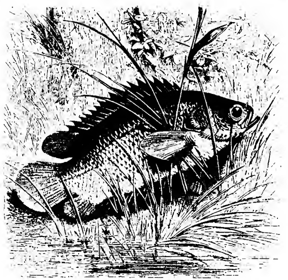
STRIATED SERPENT HEAD (⅓ nat. size).

During the time they are buried in hard mud it must be assumed that these fish become completely torpid and stop the respiratory function.

THE LABYRINTH-GILLED FISHES,—Families *ANABANTIDÆ* and *LUCIOCEPHALIDÆ*.

In the members of these two families of estuarine and fresh-water fishes, which constitute a sectional group by themselves, the apparatus for enabling them to exist for a considerable time out of the water is carried to a greater degree of complexity than in the last, and takes the form of a laminated accessory gill-like organ, situated in a chamber on each side of the head above the one containing the true gills. In these fishes the body is compressed oblong, and elevated, with medium-sized ctenoid scales. The eyes are lateral, the gills four in number, the gill-opening rather narrow; and false gills either rudimentary or wanting. The single dorsal fin, as well as the anal, has a variable number of spines; and the pelvic fins are thoracic in position. While in some cases the lateral line is interrupted, in others it is altogether wanting; and the air-bladder may be either present or absent but when developed it is generally very large, sometimes even extending into the tail. These fishes, which are of comparatively small size, are confined to Southern Asia and South Africa, and are all capable of existing for a longer or shorter period out of their native element, when they oxygenate their blood directly from atmospheric air by means of the accessory gill-like organ. Whereas some are carnivorous, others are vegetable-feeders; but all are capable of domestication, in which state they are subject to considerable variation, and several have been acclimatised in countries other than their own. The flesh of all of them is said to be eatable, and that of some is of excellent quality. On account of their brilliant coloration, and the curious habits of some of them, these fish have always attracted more than ordinary interest.

Climbing Perch. The fish to which the somewhat inappropriate name of climbing-perch (*Anabas scandens*) has long been applied by Europeans in



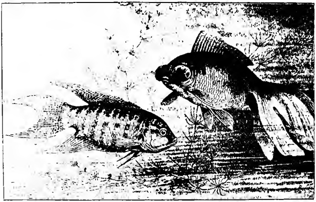
CLIMBING-PERCH ON LAND (½ nat. size).

India is the sole representative of a genus characterised by the presence of teeth on the palate, and the serration of the free margins of the opercular and preorbital bones. In form the body is compressed and oblong; the lateral line is interrupted; the single dorsal fin has its spinous portion much longer than the soft part, while in the anal fin the spines are less numerous than those on the back. The caudal fin is rounded, and the scales are rather large. In length the climbing-perch may reach at least 8½ inches, and in the adult state its general colour is dark green, usually marked with dusky bands, which disappear soon after death. It frequents both estuaries, rivers and tanks, and is distributed over India, Ceylon, Burma, the Malay Archipelago, and the Philippine Islands. That this fish can travel long distances on land, where it drags itself along by hitching its pectoral fins round the stems of grass and other herbage, in the manner indicated in our illustration, is perfectly well ascertained. With regard to its climbing powers some amount of incredulity has been expressed, but it is very noteworthy that its Malayan name (*undi-colli*) signifies tree-climber, while nearly a thousand years ago certain Arab travellers were informed of the existence in India of a fish that was in the habit of ascending cocoa-nut palms to drink their milk. Apparently the only definite record that we have of a European having witnessed such scansorial feats is from the pen of one Daldorf, who wrote that in the year 1791 he had taken one of these fishes from a moist cavity in the stem of a palmyra-palm growing near a lake. He first observed it when already five feet from the ground, struggling to ascend higher, and suspending itself by its gill-covers; and bending its tail to the left, it fixed its anal fin in the cavities of the bark, and sought by expanding its body to urge its way upwards, and its march was only arrested by the hand with which he seized it. Although there is no reason to doubt this very detailed narrative, the circumstance that later observers in India have never seen the feat repeated would seem to indicate that it is but seldom the fish takes to actual climbing. Regarding the habit of this fish in common with the serpent-heads, of burying itself in the mud of tanks, Sir J. E. Tennent writes that "in those portions of Ceylon where the country is flat and small tanks are extremely numerous, the natives are accustomed, in the hot season, to dig in the mud for fish. Mr. Whiting informs me that, on two occasions, he was present accidentally when the villagers were so engaged, once at the tank of Mulliativoe, within a few miles of Kottiar, near Trincomali, and again at a tank on the Vergel River. The clay was firm but moist, and as the men flung out lumps of it with a spade, it fell to pieces, disclosing fish from 9 to 12 inches long, which were full-grown and healthy, and jumped on the bank when exposed to the sunlight."

Paradise-Fish.

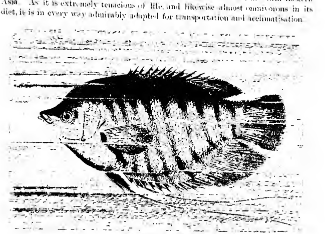
The Oriental region is the home of another allied genus of fishes (*Polyacanthus*), represented by several species, and differing from the climbing perch by the absence of teeth on the palate and the smooth margins of the preorbital and opercular bones; the mouth being small and slightly protractile. The spinous part of the single dorsal fin is much longer than the soft portion, the anal being similar; the pelvic fins have one spine and five soft rays, some of which are usually elongated; and the caudal is rounded or pointed. The lateral line, which is never complete, may be wanting. These fishes inhabit fresh waters and estuaries along the coast of South Eastern Asia, but are seldom found any great distance inland. The pretty and brightly coloured paradise-fish is an inhabitant of China and Cochin-China, and was long regarded as the representative of a distinct genus. It is, however, now known to be merely a domesticated variety of a species of *Polyacanthus*, although we are not aware that the normal form has hitherto been discovered. From our figure it will be seen that it differs from the ordinary members of the genus in the large and forked tail, and likewise in the great development of the soft rays of the dorsal and anal fins. Throughout China this fish is kept in confinement; and is even more suited to captivity than the gold-fish, as it will breed in vessels of very small capacity. It is even stated to live in water strongly impregnated with acid, and its tenacity of life is very great. When kept in dark or muddy waters the colour is generally a dull uniform brown; and it is only when living in clear water exposed to the sunlight that the golden hue and red transverse bands make their appearance, these showing at an earlier period in the males than in the females.

Gurami. On account of the excellent quality and taste of its flesh, mention must be made here of the gurami (*Osphromenus olfax*), as a well-known representative of a third genus belonging to this family. Agreeing with the members of the preceding genus in the absence of teeth on the palate, the smooth border to the preorbital and opercular, and the structure of the pelvic fins, these fishes differ by the smaller number of spines in the dorsal or anal fins, which are either fewer than the soft rays, or but very slightly exceed them. The body is moderately elevated and compressed; the small and oblique mouth is capable of a considerable degree of protrusion; and the first ray of the pelvic fins is elongated into a slender filament, the remainder being generally rudimentary. When present, the lateral line is continuous; and there is always an air-bladder. Distributed over the rivers of South-Eastern Asia, these fishes are represented in India only by a small species (*O. nobilis*) of some 4 inches in length, inhabiting North-Eastern Bengal and Assam. The gurami, which is a native of the rivers of China and the Malayan Archipelago, has, however, been introduced into several parts of India and has also been naturalised in the Mauritius, Cayenne, and Australia. It is easily recognised by its large size, great convexity of the profile of the under surface, and greenish brown colour, marked in the immature condition by four or



PARADISE FISH AND TELESCOPE FISH.

five dark vertical bands. It attains a weight of fully 20 lbs., and, when kept in clean water, is stated to be the best flavoured fresh-water fish in South-Eastern Asia. As it is extremely tenacious of life, and likewise almost omnivorous in its diet, it is in every way admirably adapted for transportation and acclimatisation.



THE GURAMI (1/[illegible] nat. size).

Fighting Fish. A fourth genus (*Betta*), distinguished by the short dorsal fin occupying the middle of the back, and without any pungent spine, the long anal, and the production of the outer ray of the five-rayed pelvic fins must also be mentioned on account of its containing the so-called fighting-fish (*B. pugnax*), which is bred by the Siamese for the sake of the sport afforded by its pugnacious propensities. Cantor writes that, "when the fish is in a state of quiet its dull colours present nothing remarkable; but if two be brought together, or if one sees its own image in a looking-glass, the little creature becomes suddenly excited, the raised fin and the whole body shine with metallic colours of dazzling beauty, while the projected gill-membrane, waving like a black frill round the throat, adds something of grotesqueness to the general appearance. In this state it makes repeated darts at its real or reflected antagonist. But both, when taken out of each other's sight, become instantly quiet. This description was drawn up in 1840 at Singapore, by a gentleman who had been presented with several by the King of Siam. They were kept in glasses of water, fed with larvæ of mosquitoes, and had thus lived for many months. The Siamese are as infatuated with the combats of these fish as the Malays are with their cock-fights, staking on the issue considerable sums, and sometimes their own persons and families. The licence to exhibit fish-fights is farmed, and brings a considerable annual revenue to the King of Siam. The species abounds in the rivulets at the foot of the hills of Penang."

Pike-Head. The small fish (*Luciocephalus pulcher*), from the fresh waters of the Malay Archipelago, shown in the accompanying illustration, is the sole representative of the second family of the labyrinth-gilled group, which differs from the first in the absence of spines from both the dorsal and anal fins. The species derives its name from the produced muzzle and general pike-like form of the head; and has its elongate body covered with moderate-sized scales, and traversed by a continuous lateral line. The teeth are small, and the gill-openings wide. The single spineless dorsal fin is very short and placed far back on the body; the pelvics consist of one spine and five rays, one of the latter being

PIKE-HEAD (nat. size).

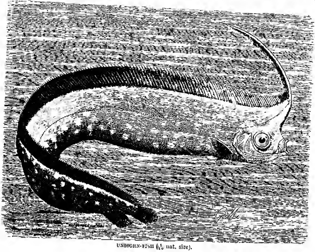
elongated; and the tail-fin is rounded. There is no air-bladder. Nothing is known with regard to the life-history of this prettily marked fish.

UNICORN AND RIBBON-FISH,—Families *LOPHOTIDÆ* and *TRACHYPTERIDÆ*.

Agreeing in their ribbon-shaped bodies, and also in the extension of the dorsal fin from the head to the end of the tail, the unicorn and ribbon-fishes are thereby easily distinguished from all the preceding forms, although they differ so much from one another as to be entitled to form distinct families, each of which is regarded by Dr. Günther as representing a sectional group.

Unicorn-Fish. The single representative of the first family (*Lophotes cepedianus*) differs from the whole of the members of the subclass hitherto described, in that the vent is situated at the hinder extremity of the body, close to the tail, with a small anal fin immediately behind it. The pelvic fins are very minute and thoracic in position; the caudal is also small and rounded; the mouth is incapable of protrusion; teeth are present on the jaws, palatines, and vomers; and there is an air-bladder. The most striking peculiarity about this strange fish is the elevation of the crown of the head into a high crest surmounted by an exceedingly long and recurved spine forming the commencement of the dorsal fin. The bones and flesh are firm; the general colour is silvery, with lighter spots, but the fins are rosy; and the total length is at least 5 feet. This fish, which has been taken in the Atlantic off Madeira, and also in the Sea of Japan, probably dwells at a considerable depth, although not so far down as the ribbon-fishes. Its habits are unknown.

Ribbon-Fishes. From the unicorn-fish the members of this family may be distinguished by the absence of an anal fin, and by the caudal (which, as in our figure, is rarely preserved in the adult state) being either rudimental, or small and bent up above the axis of the body in a fan-like manner. The band-like body, which may measure as much as 15 or 20 feet in length, with a depth of a foot and a breadth of not more than an inch, terminates in a short and deep head, furnished with large lateral eyes, and a small mouth; the teeth being feebly developed. The high dorsal fin is composed of a very numerous series of rays, which are neither articulated nor branched, and has a detached portion on the crown of the head elevated into tall filaments,[1] and the thoracically-placed pelvic fins may consist either of several rays, or be reduced to a single long filament. Scales are wanting; and the numerous vertebræ as well as the other bones, are remarkable for their softness and loose structure; the flesh being likewise of a flabby consistence. The young, which are not unfrequently found at the surface of the ocean, are very unlike the adults, having the body more like that of an ordinary fish, but remarkable for the enormous development of the rays of the front part of the dorsal and pelvic fins, and in a minor degree those of the caudal likewise. The dorsal rays are, indeed, several times the length of the whole fish, and are furnished at intervals with barb-like dilatations. Most ribbon-fish are silvery in colour, with rosy fins. They are divided into three genera, of



UNICORN-FISH (1/10 nat. size).

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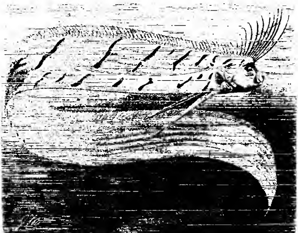
[1] In our figure this part is represented as connected with the rest of the fin.

which *Trachypterus* has well-developed pectoral fins, while *Stylophorus* has the tail produced into an exceedingly long filament; *Regalecus* being distinguished by the reduction of the pelvic fins to a pair of long filaments with dilated extremities, and the small size or rudimentary condition of the caudal. Our figured example (*R. banksi*) belongs to the third genus, and has the body of considerable relative depth, but in a much smaller Indian form (*R. russelli*) the body is so slender as to have a rod-like appearance. Banks's ribbon-fish appears to be only known from specimens cast ashore on the British coast, the first of these having been stranded at Whitby in January 1759, since which date only fifteen other examples were recorded up to 1878. All these fishes are, indeed, known almost entirely from examples found in a dead or dying condition on the surface of the ocean, or cast ashore by the waves. In this state the whole of their tissues are so disintegrated and broken that the body can scarcely be lifted whole from the water, and it is thus evident that ribbon-fishes are inhabitants of the lower strata of the ocean, although at what precise level they live has not yet been ascertained. They are found in all seas, but are mostly of very rare occurrence on the surface, the single representative of the genus *Stylophorus* being only known by one example captured in the early part of this century near Cuba; while the same is the case with regard to Russell's ribbon-fish from Madras. That the young are also deep-

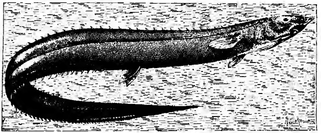


BANKS'S RIBBON-FISH ($\frac{1}{12}$ nat. size).

sea fishes is, as Dr. Günther remarks, perfectly evident from their filamentous fins, which would be irretrievably damaged if their owners did not live at depths where the water is perfectly undisturbed. From the expansion of the extremities of the pelvic fins, Banks's ribbon-fish has been named the oar-fish; while from a supposed idea that it accompanied the shoals of those fish, it has likewise been designated the king of the herrings. It has been suggested that large ribbon-fish floating on the surface have given rise to many of the reports regarding the sea-serpent; but, as Dr. Günther pertinently points out, such dead or dying creatures do not by any means accord with the active movements generally attributed to that mythical monster. Still, however, we believe that a stranded ribbon-fish has been mistaken for a dead sea-serpent.

THE THORNBACKS,—Family *NOTACANTHIDÆ.*

The last family of the great division of spiny-finned fishes we have been considering in the foregoing paragraphs includes only the deep-sea fishes

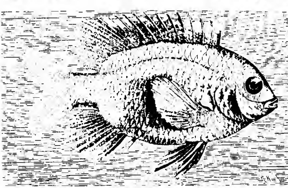


RISSO'S THORNBACK (¼ nat. size).

known as thornbacks, all of which are referred to the single genus *Notacanthus*. These fishes are very abnormal forms, agreeing only with the more typical members of the suborder to which they are referred in the presence of spines in the median fins. Possessing an elongate and somewhat compressed body, covered with minute scales, they are specially characterised by having the dorsal fin composed of a series of low isolated spines, without any soft portion; while the anal is elongated, with a great number of spines, the pelvic fins being abdominal in position, and comprising more than five soft rays, in addition to several unarticulated ones. In the head the muzzle is prolonged in advance of the mouth; the moderate-sized eyes are lateral in position; and the teeth are small and weak. The six known species range from the Arctic Ocean to the Mediterranean, Atlantic, and South Pacific. All are deep-sea fishes, probably dwelling at depths of from a hundred to five hundred fathoms; although one specimen taken to the south of Yokohama during the voyage of the *Challenger* is stated to have come from a depth of nearly nineteen hundred fathoms.

THE WRASSE-LIKE FISHES.—Families *POMACENTRIDÆ, LABRIDÆ, CHROMIDIDÆ,* etc.

In almost all the families of spiny-finned fishes hitherto described the lower pharyngeal bones are completely separated from one another, whereas in the four families remaining for consideration these are united with one another. It has been considered that this difference was of sufficient importance to justify the reference of the families with united pharyngeals to a subordinal group of equal rank with one containing those in which these bones remain distinct, but we prefer to follow Day in regarding the group now to be considered merely as a section of the suborder which includes all the other spiny-finned fishes. That this is the correct view is proved by the circumstance that in one aberrant genus of perches (*Gerres*) some of the species have the lower pharyngeal bones separate, while in others they are united. In the three families constituting the present group there is a single dorsal fin, in which the number of spines and soft rays is nearly equal, while the anal is usually similar in character to the soft dorsal; and the pelvic fins are thoracic in position, and include one spine and five soft rays.

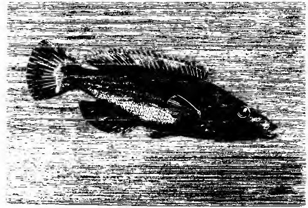


SILVER-DOTTED POMACENTRUS (½ nat. size).

Pomacentrus The first of the families of the present sectional group takes its name from the genus *Pomacentrus*, which, together with the allied genera, includes tropical fishes mainly frequenting the neighbourhood of coral-reefs and islands, and thus closely resembling the scaly-finned fishes (p. 343) in their mode of life; a few species of the family range, however, into the seas of the temperate zones. As an example of the typical genus, we figure *P. scolopsis*, from the Malayan seas and Polynesia. As a family, these fishes are specially characterised by the presence of false gills and ctenoid scales. In form, the body is more or less short and compressed; there are weak teeth in the jaws but none on the palate, and there is an air-bladder. The family is represented by eight genera and considerably over a hundred species; and the genera may be divided into groups, according as to whether all or some of the opercular bones are serrated at the edges or are all simple; *Pomacentrus* belonging to the intermediate group, in which the preopercular is serrated, while the edges of the other bones of the gill-cover are entire. In a fossil state the family is represented by an extinct genus from the middle Eocene deposits of Monte Bolca. *Pomacentrus* is the largest genus of the family, its representatives ranging over the tropical seas of both hemispheres. Curiously enough, not only do these fishes resemble the scaly-finned fishes in their mode of life, but they are very similarly coloured, so much so indeed, that in some instances actually the same pattern of coloration is common to members of the two families. This, as remarked by Dr. Günther, is one of many instances showing that the coloration of animals depends to a great extent on their mode of life and natural surroundings. All these fishes are carnivorous, subsisting on various small marine animals; those furnished with compressed teeth probably browsing on the coral-polyps.

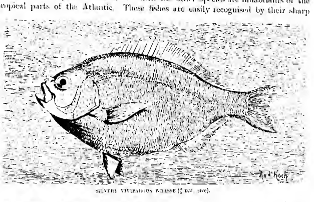
Wrasses. Distinguished from the preceding family by their cycloid scales, the wrasses form an extensive group (*Labridæ*), many of the members of which may be easily recognised by their greatly thickened lips, sometimes provided with an internal fold; and from this character they derive their German title of lip-fishes. False gills are present, and the true gills, three and a half in number on each side. The body is oblong or elongate, and while teeth are present in the jaws they are absent on the palate. In the single dorsal fin the number of spines is usually equal to that of the rays; the anal is similar to the soft dorsal, and an air-bladder is present. Littoral in their habits, the great majority of the wrasses are found in tropical and temperate seas, none occurring within the limits of the polar seas. Rocks and coral-reefs are their favourite haunts, most of them feeding chiefly on molluscs and crustaceans, for crushing the shells of which their teeth are specially adapted. In many kinds there is an additional pointed curved tooth at each angle of the upper jaw, used for holding a shell against the front and side teeth, by which it is crushed. The majority of the wrasses are beautifully coloured fishes, decorated not only with transient iridescent hues on the scales, but likewise with permanent colours formed by the deposition of pigment in the tissues. Some of the species grow to a large size, specimens weighing upwards of 50 lbs.; and it is these larger species which are most esteemed as food-fishes, the flesh of the smaller kinds being of inferior quality. In a fossil state wrasses date from the middle Eocene of Monte Bolca, where remains referable to the existing genus *Labrus* occur; while an extinct Eocene genus from North America appears to be the ancestral form of the existing black fish (*Tautoga*). An allied extinct family is represented by *Phyllodus*, from the Cretaceous and lower Eocene of Europe—distinguished by the flattened leaf-like pharyngeal teeth—as well as by several other more or less nearly related Tertiary types.

True Wrasses. As it would be quite impossible in our limited space to describe even a few of the numerous genera of wrasses, we must content ourselves with saying that these are arranged in groups according to the structure of the anterior teeth, and devote our remaining observations mainly to the typical wrasses constituting the genus *Labrus*. In this genus, of which the figured striped or red wrasse (*L. mixtus*) may be taken as a well-known British example, the body is compressed and oblong in form, with the moderate-sized scales arranged in more than forty transverse rows; the muzzle is more or less sharply pointed; the cheeks and opercular bones are covered with imbricating scales, which are, however, wanting or but few in number on the interopercular; and the conical teeth are arranged in a single row in the jaws. The spines of the dorsal fin are numerous, varying from thirteen to twenty-one, and are all of approximately equal height; there are three spines in the anal fin; and the lateral line is continuous. In the young, the edge of the preopercular bone is serrated. These wrasses are chiefly


STRIPED WRASSE (⅓ nat. size).

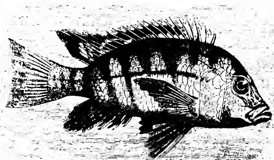
characteristic of the Mediterranean area, gradually diminishing in the more northern seas of Europe, and being quite unknown in those of India. The striped wrasse exhibits a remarkable sexual variation of colour; the males usually having the body marked with blue streaks or a blackish band, while in the females the back of the tail shows two or three blackish blotches. The other British species is the Ballan wrasse (*L. maculatus*), in which the general colour is bluish green, the scales being margined with reddish orange, and the fin-rays also of the latter tint. Couch writes that the Ballan wrasse "frequents deep gullies among rocks, where it shelters itself among the larger kinds of seaweeds, and feeds on crabs and other crustaceous animals. It takes a bait freely, and fishermen remark that when they first fish in the place they take but few, and those of large size; but on trying the same spot a few days after, they catch a great number, and those smaller, from which they conclude that the large fish assume the dominion of a district, and keep the younger at a distance." The gold sinny (*Crenilabrus melops*) is a British example of a second genus, distinguished by the serrated edge of the preopercular. Another well-known member of the family is the black-fish (*Tautoga onitis*), of the Atlantic coast of North America, so named on account of its blackish brown colour, and the sole representative of a genus characterised by the naked opercular, the rudimental scales on the cheek, and the double row of teeth in the jaws.

Parrot-Wrasses. Since their Mediterranean representative (*Scarus cretensis*) was a fish held in high estimation among the ancients, brief mention must be made of the parrot-wrasses, of which the other species are inhabitants of the tropical parts of the Atlantic. These fishes are easily recognised by their sharp beak, caused by the coalescence of the teeth; and also by the lower jaw projecting in front of the upper. Of the splendidly coloured Mediterranean species Dr. Günther writes that "it was most plentiful and of the best quality in the Carpathian Sea, between Crete and Asia Minor, but was not unknown, even in early times, on the Italian coasts though Columella says it seldom passed beyond Sicily in his day. But in the reign of Claudius, according to Pliny, Optatus Elipentius brought it from the Troad, and introduced it into the sea between Ostium and Campania. For five years all that were caught in the nets were thrown into the sea again, and from that time it was an abundant fish in that locality. In the time of Pliny it was considered to be the first of fishes; and the expense incurred by Elipentius was justified, in the opinion of the Roman gourmands, by the extreme delicacy of the flesh." This fish feeds on seaweed; and the mastication required to reduce this to a pulp probably gave rise to the old idea that it was a ruminant.



SILVERY VIVIPAROUS WRASSE (⅔ nat. size).

Viviparous Wrasses. For the want of a better one, the members of the small family *Ditrematidæ* may be termed, on account of their peculiar reproductive arrangements, viviparous wrasses. Agreeing with the wrasses in the presence of false gills and the cycloid scales, they differ in having four gills, and the anal fin furnished with three spines and numerous soft rays. In form, the compressed body is either elevated or oblong, and the lateral line continuous. The single dorsal fin has a spinous portion in front, and a scaly sheath along the base, separated by a groove from the body-scales. Small teeth are present in the jaws, but the palate is toothless. Generally not exceeding a pound in weight, these fishes are confined to the temperate region of the North Pacific, where they are much more numerous on the American than on the Asiatic side. While the majority belong to the genus *Ditrema*, of which an example (*D. argenteum*) from San Francisco is represented in the illustration, one species constitutes the genus *Heterocarpus*, distinguished by the number of dorsal spines being from sixteen to eighteen, instead of only from seven to eleven. All these fish produce living young, which are contained in the sheath of the ovaries, instead of in the oviduct.



TRISTRAM'S CHROMID.

Chromids. Although some members of the preceding family may occasionally enter rivers, the chromids, family *Chromididæ*, differ from all the other fish with united lower pharyngeals in being exclusively fresh-water forms. Their distribution is somewhat peculiar, and very similar to that of the lung-fishes (exclusive of the Australian form). Thus they are found in the rivers of Tropical America and Africa, together with Madagascar, Syria, and Palestine, one outlying genus occurring in India, and it may be remarked that all the genera from the New World are distinct from those of the Old World. Mostly of comparatively small size, although one species of the type genus from the Nile grows to a length of about twenty inches, the chromids may be distinguished from all the other three families of the present group by the absence of false gills. The body, which is somewhat variable in form, is generally covered with ctenoid scales, although in some cases these may be cycloid; and the lateral line is more or less interrupted.

In the single dorsal fin the spinous portion usually exceeds the soft in extent; the anal fin having three or more spines, and its rayed portion being similar to the soft dorsal. The jaws are provided with small teeth, but the palate is smooth, and the number of gills is four. In some species the teeth are lobate and the intestines complicated by many foldings; these types being vegetable-feeders while all the remainder are carnivorous. Among the best known representatives of the typical genus *Chromis* is the so-called bulti of the Nile (*C. niloticus*), which is one of the largest members of the family; while Tristram's chromid (*C. tristrami*) here figured is from salt and other lakes in the Sahara and Ashanti. As a genus, *Chromis* is distinguished by its lobate teeth, the presence of only three spines in the anal fin, and the scaly gill-cover; and it therefore belongs to the vegetable-feeding group. Nineteen existing genera have been described; and the family appears to be represented by one, or perhaps two extinct generic types from the middle Eocene of Monte Bolca, in Italy.

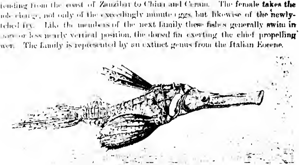
THE TUFT-GILLED AND COMB-GILLED FISHES,—Suborders LOPHOBRANCHII AND PLECTOGNATHI.

The two small subordinal groups of fan-finned fishes now to be noticed have been generally placed after the soft-finned fishes, but from recent investigations into their anatomy it appears more probable that they are highly specialised types related to the spiny-finned group.

THE MAILED TUBE-MOUTHS,—Family *SOLENOSTOMATIDÆ.*

A few small fishes from the Indian Ocean constituting the genus *Solenostoma* are the sole representatives of the first family of the suborder Lophobranchii; the distinctive features of that subordinal group being as follows. The body is invested in a segmented bony dermal skeleton, and the bones of the gill-cover are reduced to a single plate. The gill-openings are small, and the gills themselves consist of small, rounded tufts springing from the gill-arches; while the muscular system is characterised by its very slight development. The simple air-bladder, when present, resembles that of the spiny-finned group in being unprovided with a duct communicating with the pharynx; and the prolonged muzzle terminates in a small toothless mouth, in which the bones are arranged as in the group last named. In the family under consideration the gill-openings are wide; the rays of the first of the two dorsal fins are not articulated; and the whole of the other fins are well developed. The mailed tube-mouths take their title from the great elongation of the tube-like muzzle; the compressed body having a very short tail, and, like the head, being covered with a thin skin, beneath which are the large bony plates, marked with a radiate pattern. The soft dorsal and anal fins arise from boss-like elevations of the hinder part of the body; the pelvic fins, which are placed close together in the same vertical line as the tall first dorsal, and have seven rays, are separate from one another in the males, but in the opposite sex have their inner edges joined to the skin of the chest so as to form a pouch for the reception of the eggs. The air-bladder is wanting. A female of the blue-finned species (*S.*

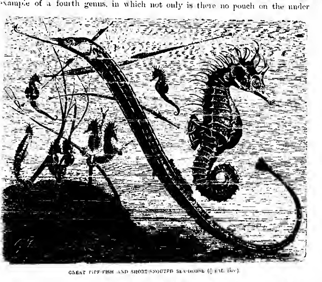
cyanopterum) is shown in the accompanying illustration; the range of this form extending from the coast of Zanzibar to China and Ceram. The female takes the whole charge, not only of the exceedingly minute eggs, but likewise of the newly-hatched fry. Like the members of the next family these fishes generally swim in a more or less nearly vertical position, the dorsal fin exerting the chief propelling power. The family is represented by an extinct genus from the Italian Eocene.



BLUE-FINNED TUBE-MOUTH (nat. size).

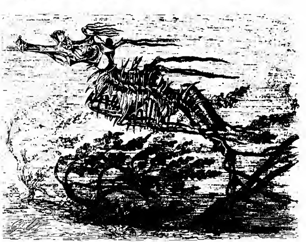
THE PIPE-FISHES AND SEA-HORSES.—Family *SYNGNATHIDÆ*.

From the members of the preceding family the pipe-fishes may be distinguished by the reduction of the gill-opening to a very small opening at the superior hinder angle of the gill-cover, as well as by the single soft dorsal fin, and the absence of the pelvic fins; some of the other fins being likewise wanting in certain genera. Mainly marine, although frequently entering brackish, and more rarely fresh waters, these strange fishes are to be found on the coasts of tropical and temperate seas in such situations as, from the abundance of seaweed, offer them sufficient shelter. They are naturally poor swimmers, and if carried away from protective covert may be borne helplessly out to the open ocean by the action of currents. Unlike the tube-mouths, the males take charge of the eggs and young, being often provided with a pouch formed by a fold of skin arising from each side of the body and tail, and joined together in the middle line; in the sea-horses this pouch being completely closed, save for a small aperture in front. In this receptacle the eggs are deposited, and remain there till hatched. The typical genus, as well as *Siphonostoma*, is represented in a fossil state in the middle Eocene of Monte Bolca, where there likewise occurs an extinct genus of sea-horses. Including several genera, the pipe-fishes are characterised by the absence of prehensile power in the tail, which generally terminates in a fin. In the typical genus *Syngnathus*, as represented by the great pipe-fish (*S. acus*) shown in our illustration, the body is marked with more or less distinct longitudinal ridges, among which the one down the back is not continuous with that on the tail. The pectorals are well developed, the caudal present, and the dorsal fin placed nearly or exactly above the vent. In the males the pouch is fully developed, and of the type described above. The great pipe-fish is a common species in European seas, extending westwards across the Atlantic and southwards to the Cape, and grows to a length of a foot and a half. As an example of a second genus, we may mention the deep-nosed pipe-fish (*S. typhle*), of the British seas, distinguished by the upper ridge on the tail being continuous with the lateral line, but not with the dorsal ridge. In the tropical genus *Doryichthys*, as in some others, we find that the eggs are only glued to the skin of a broad groove on the under surface of the males, instead of being protected by a closed pouch. The slender straight-nosed pipe-fish (*Nerophis ophidium*), which may not unfrequently be seen served up among a dish of whitebait, is a British example of a fourth genus, in which not only is there no pouch on the under surface of the males, but the body is rounded and nearly smooth, and the caudal fin either rudimentary or wanting. All the pipe-fishes are carnivorous in their diet; and it is stated that in those species provided with a pouch, the fry will return to this for shelter till a considerable time after birth. The pipe-fishes swim about slowly in a very peculiar manner, more generally vertically or in an inclined position than horizontally, contorting their bodies into every conceivable kind of posture, and poking their long snouts inquisitively into bunches of sea-weed in their search for food.



GREAT PIPE-FISH AND SHORT-SNOUTED SEA-HORSE (½ nat. size).

The prehensile structure of the tail is the chief difference between sea-horses and pipe-fish, although in all the existing representatives of the former group there is no caudal fin. The sea-horses are divided into several genera, of which the typical one is best known by the short-snouted sea-horse (*Hippocampus antiquorum*), ranging from the Atlantic and Mediterranean to Australia, and occasionally found in the British seas. In this genus the body is more or less compressed and deep, with its investing bony shields raised into tubercles or spines of variable length; while the back of the head is compressed into a crest, terminating in a well-marked knob. Small pectoral fins are present, and the males have a pouch beneath the tail, with its aperture near the vent, in which to carry the eggs. The curious resemblance presented by the heads of these fishes to that of a horse has obviously given rise to their popular name. They are represented



FUCUS-LIKE SEA-HORSE (⅔ nat. size).

by about a score of species. A remarkable instance of resemblance to their natural surroundings is afforded by the three representatives of an Australian genus of sea-horses, one of which (*Phyllopteryx eques*) is shown in the accompanying illustration. In these fishes the body may be either compressed or as broad as deep; some or all of its smooth bony plates being furnished with long spine-like processes projecting from its edges, and many of these terminating in irregular leaf-like appendages. There are a pair of spines on the muzzle, and others above the eye; pectoral fins are present; and the tail is about equal in length to the body. In the absence of a pouch, the eggs are embedded in soft membranous skin on the under surface of the tail. These sea-horses closely resemble the colour of the seaweeds to which they attach themselves, while the filamentous appendages of their spines appear as if they were actually a part of the vegetable growth. These species are of relatively large size, attaining a length of as much as a foot.

FILE-FISHES AND COFFER-FISHES,—Family *BALISTIDÆ*

With the file-fishes and their allies we come to the first of the two families constituting the suborder Plectognathi, of which the following are the distinctive characters. In the head the bones are completely ossified, while in the rest of the skeleton they are incompletely hardened; the number of vertebræ being few. The small gill-openings are situated in front of the pectoral fins, and the gills themselves are pectinate; the mouth being narrow, with some of the bones of the upper jaw united, and in certain cases both jaws prolonged to form a beak. There is generally a single soft-rayed dorsal fin, placed far back on the body, and situated immediately above the anal; and there may be remnants of a spinous dorsal; while the pelvic fins, when retained at all, take the form of simple spines. The skin may be either entirely naked, covered with rough scales, invested in a complete cuirass of plates composed of true bone, or dotted over with bony spines. There is no duct connecting the air-bladder with the pharynx. As a family, the file-fishes and their allies are specially distinguished by the presence of a small number of distinct teeth in the jaws. Their bodies are either compressed or angulated, with a somewhat produced muzzle; more or less distinct vestiges of a spinous dorsal and pelvic fins generally occur; and the skin may be either rough or spiny, or the whole body invested in a bony cuirass. These fishes, which are of medium size, range over all tropical and temperate seas, although more numerous in the former than in the latter, and may be divided into three subfamilies in each of which we notice an example. Extinct generic types date from the period of the lower Eocene, while the file-fishes themselves are recorded from the middle Eocene of Monte Bolca.

The first subfamily is typically represented by *Triacanthus brevirostris*, from the Indian Ocean, the other genera being from the Australian seas. The special characters of the group are to be found in the compressed form of the body, and its covering of rough, scale-like plates, as well as in the presence of a pair of strong spines representing the pelvic fins, the type genus being distinguished by having from four to six spines in the spinous dorsal fin. The typical file-fishes (*Balistes*) belong to a group of three genera in which the body is compressed, and covered either with a rough skin or movable scale-like plates; and the pelvic fins are either wanting or represented merely by a single median swelling on the abdomen. These fishes are distributed over all tropical and subtropical seas, the first two genera including a very large number of species. Whereas in the typical genus there are three spines to the dorsal fin, and the chin is devoid of a barbel, *Monacanthus* differs in the reduction of the dorsal spines to two or one, and *Anacanthus*, which has a single dorsal spine, is distinguished from both the others by the barbel on the chin. In many districts the flesh of these fishes, if eaten, gives rise to symptoms of most acute poisoning. Many of the species are beautifully ornamented with symmetrical markings; and while the majority are of small size, some attain as much as a couple of feet in length. Of the members of the typical genus Dr. Gunther writes that, both jaws are armed with eight strong incisor-like and obliquely truncated teeth, by means of which these fishes are enabled to break off pieces of the corals on which they feed or to chisel a hole into the hard shells of molluscs, in order to extract the soft parts. They destroy an immense number of molluscs, thus becoming most injurious to the pearl-fisheries. The first of their three dorsal spines is very strong, roughened in front like a file, and hollowed out behind to receive the second much smaller spine, which, besides, has a projection in front at its base fitting into a notch of the first. Thus these two spines can only be raised or depressed simultaneously, and the first cannot be forced down unless the second has been previously depressed. The latter has been compared to a trigger, hence a second name—trigger-fish—has been given to these fishes. Two Atlantic species of the genus are now and then met with on the British coasts.

The box-like coffer-fishes (*Ostracion*), of which there are rather more than a score of species from the tropical and subtropical seas, alone represent the third and last subfamily, and are easily recognised by the enclosure of the angulated body in a complete cuirass formed of six-sided bony plates with their edges in juxtaposition, thus forming a mosaic-like pattern. Both the spinous dorsal and the pelvic fins are wanting, although their position may be indicated by prominences. In the whole backbone there are but fourteen vertebræ, of which the last five are very short, while those in the front of the series are much elongated; and the ribs are entirely wanting. In some of the species the cuirass is marked by three, and in others by four or even five ridges; but in other cases it is armed with long spines, which vary in length according to the age of their owner. A species (*O. quadricornis*) is figured in the coloured Plate.

THE GLOBE-FISHES AND SUN-FISHES,—Family *DIODONTIDÆ*.

Unlike as they are in external appearance, the spine-clad globe-fishes and the huge flattened sun-fishes are referred to a single family, distinguished from the last by the bones of the jaws being confluent and modified into a cutting beak, which may or may not have a median suture, the dentition taking the form of dental plates composed of thin parallel layers. The body is more or less shortened; a spinous dorsal, anal, caudal and pectoral fins are developed, but the pelvics are wanting. The external covering may take the form either of a number of small or large spines, or of plates; and the air-bladder may be either present or absent. Inhabitants of tropical and subtropical seas, with the exception of a few found in the fresh waters of the same regions, the members of this family are mostly small or medium-sized forms, although this is by no means the case with the sun-fishes. In many of them the flesh is of a highly poisonous nature, at least during certain seasons of the year. Like the preceding, the present family may be divided into three groups or subfamilies, the first of which is represented only by the sac-fish (*Triodon bursarius*) of the Indian seas, which takes its name from the sac formed by the dilatable skin of the abdomen; this sac being supported by the pelvic bone, and filled with air at the will of the fish, although its lower portion consists merely of a flap of skin into which no air can enter. The dental plate of the upper jaw is divided by a median suture, while that of the lower jaw is

continuous. The elongate tail terminates in a forked fin; and the body is invested with spiny bony plates, which do not overlap one another. The single species, which may attain a length of 20 inches, ranges over the Indian and Malayan seas, and is of a general brown colour, with a spot of variable colour on the sac, and the fins yellow.

Globe Fishes. The essential characteristics of the globe-fishes, which form the second subfamily, are that the tail and its fin are distinct and well developed, and that a portion of the œsophagus is highly distensible and capable of being inflated with air. All the globe-fishes, or, as they are sometimes called, sea-hedgehogs, are easily recognised by the short and cylindrical or rounded form of the body; which is generally covered with a scaleless skin bearing a number of spines of variable size. When these spines are of large size, they are spread uniformly over the whole body, but when small they are partial in their distribution. These fishes are divided into two groups, according to the nature of the dental plates. In the first, or small-spined group, as typified by the genus *Tetrodon*,—of which a species is represented in the lower figure of the coloured Plate,—the dental plate of each jaw is divided by a median suture, and the spines are frequently very small, and may be even altogether absent; many of the species being very brilliantly coloured. One member of the genus inhabits the rivers of Brazil, and a second those of West Africa and the Nile, while a small form is found in the brackish-water estuaries of India. According to Day, the flesh of some of the species is poisonous, while that of other kinds is eaten by the Andamanese and Burmese. In the second group, of which the porcupine globe-fish (*Diodon hystrix*) is shown in the lower figure of the coloured illustration, the dental plates in the jaws are undivided, and the spines are large and frequently erectile. In addition to the undivided dental plates on the edge of the jaws, in the members of this group there is another crushing plate in the middle of the palate, opposed by a similar one in a corresponding position in the lower jaw; these plates being divided by a median suture, and from their laminated structure forming most admirable triturating instruments. The porcupine globe-fish, which may measure fully a couple of feet in length, is distributed over both the Atlantic and Indo-Pacific Oceans, where it is accompanied by the smaller spotted globe-fish (*D. maculatus*). Fossil diodons have been discovered in the Miocene strata of Malta and Sicily, as well as in the middle Eocene of Monte Bolca, and in other Eocene beds on the coasts of Algeria and Arakan; while an extinct genus has also been recorded from the Italian Eocene. In their normal state the globe-fishes have rather elongated cylindrical bodies, but they are able to assume a globular form by swallowing air, which passes into the œsophagus and blows out the whole animal like a balloon, with the spines standing out at right angles from the tense skin. In this condition the fish naturally floats back-downwards, and it is then driven to and fro on the ocean-surface by waves and currents in a perfectly helpless condition; although the bristling spines render it perfectly safe from all attack. The distention is, therefore, evidently for the purpose of defence; and it has been suggested that when swimming below the surface these fishes may inflate themselves in a similar manner by swallowing water instead of air. When desirous of returning to its normal condition, the fish expels the air from the œsophagus through the mouth and gill-openings; a loud, hissing noise being produced by the expulsion.

Sun-Fishes

The gigantic sun-fishes (*Orthagoriscus*), which are pelagic forms distributed throughout the whole of the temperate and tropical seas, alone represent the third subfamily, and are distinguished by the extremely short and truncated tail, the confluence of all the median fins, and the short and highly compressed body, the dental plates of the jaws being undivided. The skin is either rough or smoothly tesselated, and incapable of distention with air; there are no pelvic fins; the air-bladder is wanting; and there is an accessory opercular gill. As in the globe-fishes, there are no pelvic bones in the skeleton, and the vertebral column is remarkable for its extreme shortness, there being only seventeen segments in the whole series, of which seven belong to the tail. In all the members of the suborder the spinal cord is noticeable for its shortness; but in the sun-fishes this abbreviation has been carried to such an extent that the whole cord is little more than a conical backward appendage of the brain. The creatures considered to be very young sun-fish are utterly unlike the adult form, having an enormous eye, and the head and body armed with a number of large spine-like projections. The caudal fin is not developed till much later than the dorsal and anal, which in the adult are very short, of great height, and placed opposite to one another at the hinder end of the body. The common sun-fish (*O. mola*), which has a rough, finely granulated skin, attains very large dimensions, an example caught off the coast of Dorsetshire in 1846 measuring 7½ feet in length.

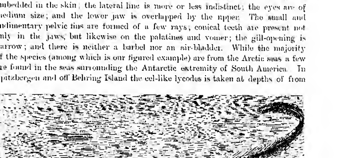
Far rarer is the oblong sun-fish (*O. truncatus*), which is, indeed, one of the scarcest objects in museums. It is readily distinguished by its smooth, tesselated skin, and the more elongated form of the body, the entire length being nearly three times the breadth. An example of this fish, weighing 500 lbs., was taken in Plymouth Sound in the year 1734. Both species appear to feed on small pelagic crustaceans. In a fossil state sun-fishes have been recorded from strata of lower Miocene or upper Eocene age in Belgium.

THE SOFT-FINNED FISHES,—Suborder **Anacanthini**.

This suborder, which includes the important families of the flat-fish and cods, is characterised by the median and pelvic fins being entirely composed of soft jointed rays; the pelvic fins if present, being either jugular or thoracic in position; and the air-bladder, when developed, having no duct communicating with the œsophagus. It should, however, be mentioned, that a fresh-water Australian fish (*Gadopsis*) forms an exception as regards the structure of its fins having spines in the anterior portion of both the anal and dorsal. The suborder is divided into two sections, according to whether the head and body are symmetrical or distorted, the first representatives of the former section being

Family *LYCODIDÆ*.

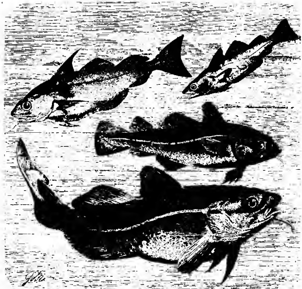
This unimportant family, for which there is no proper English name, includes small littoral fishes much resembling blennies in general appearance, and mostly characteristic of high latitudes, although a few occur within the Tropics. As a family they are characterised by the confluence of the median fins; by the pelvic fins, if present at all, being of small size, jugular in position, and attached to the pectoral arch; while the gill-opening is narrow, and the gill-membrane attached to what is known as the isthmus, that is to say, the space on the chest intervening between the two branches of the lower jaw and the gill-openings. In the typical genus, of which a species (*Lycodes muraena*) is represented in our illustration, the elongated body is either naked or covered with minute scales embedded in the skin; the lateral line is more or less indistinct; the eyes are of medium size; and the lower jaw is overlapped by the upper. The small and rudimentary pelvic fins are formed of a few rays; conical teeth are present not only in the jaws, but likewise on the palatines and vomer; the gill-opening is narrow; and there is neither a barbel nor an air-bladder. While the majority of the species (among which is our figured example) are from the Arctic seas a few are found in the seas surrounding the Antarctic extremity of South America. In Spitzbergen and off Behring Island the eel-like lycodes is taken at depths of from 350 to 500 fathoms. In the allied genus *Gymnelis*, which is of especial interest from a geographical point of view on account of one species inhabiting the seas around Greenland, while the second comes from the Straits of Magellan, there are no pelvic fins, and the two jaws are of equal length. A third genus, *Uronectes*, from Baffin Bay, agrees with the last in the absence of pelvic fins, but differs in that the lower jaw is the longer. Three other genera are respectively represented by species from Panama, Australia, and the Straits of Magellan.



EEL-LIKE LYCODES (⅔ nat. size).

THE COD TRIBE—Family *GADIDÆ*.

Equalled only in this respect by the mackerels, flat-fish, salmon, and herrings, the cod tribe form a family of the utmost importance from a commercial point of view, and therefore demand a somewhat detailed notice. They are specially characterised by the pelvic fins being generally composed of several rays; and by the caudal being either free, or, if united with the median fins, by the first dorsal being divided into two moieties. More or less elongate and subcylindrical in form, the body is covered with small cycloid scales; there are either one, two, or three dorsal fins, occupying nearly the entire length of the back, the rays of the hindmost being well developed; the anal is either single or divided; and the jugular pelvic fins are usually formed of several rays, but if reduced to filaments there is always a double dorsal. The gill-opening is wide, and the gill-membrane in



HADDOCK, WHITING, AND YOUNG AND ADULT COD (⅛ nat. size).

most instances not attached to the isthmus; while if false gills are present at all they are either glandular or rudimental. As a rule, there is an air-bladder. Mostly marine, the members of the cod family are mainly characteristic of the Arctic and Temperate seas, where they are comparatively shallow-water fishes. There are, however, a certain number of deep-water types among the family, and these have a much more extensive distribution, some of them occurring in the tropical Indian seas. The fresh-water forms are limited to two or three. Although the flesh of the cod tribe is by no means remarkable for its delicacy or flavour, it affords a most wholesome and substantial food, and as it possesses the property of taking salt readily, it is more valuable as a food-supply than would otherwise be the case. Moreover, the liver of the cod is of especial value as the source of a highly strengthening medicinal oil, greatly increasing the value of the fishery of this species, which affords employment to a host of men on both sides of the Atlantic. The family is divided into more than twenty distinct genera, but in this work our attention will be chiefly concentrated on those containing species of commercial importance. Geologically the group is not a very ancient one, the oldest known forms, all of which are referred to extinct genera, occurring in the London Clay and other deposits of lower Eocene age.

Cod. The common cod (*Gadus morrhua*), of which a half-grown and an adult example are shown in the two lower figures of our illustration, is the typical representative of a genus primarily characterised by the presence of three dorsal and two anal fins, and of teeth on the vomer, the palatine bones being toothless. The degree of elongation of the body is moderate, and the narrow pelvic fins include six or more rays. In the majority of the eighteen species recognised by naturalists there is a single barbel dependent from the chin, but in some forms this is absent. The species are distributed over the Arctic and Temperate regions of the Northern Hemisphere. The common cod belongs to a group of several species characterised by the upper jaw being the longer and the outer series of upper teeth stouter than the inner ones, its barbel is relatively long. Cod from the British seas and German Ocean are usually greenish or brownish olive in colour, with a number of yellowish or brown spots; but more to the north darker, and often uniformly coloured specimens are more common, while in the race from Greenland, Scandinavia, and Northern Norway there is frequently a large irregular black patch on each side of the body. As a rule, cod vary in length from 2 to 4 feet, and may weigh as much as 100 lbs.; but a specimen out of condition, caught near Wick in the year 1872, measured upwards of 4½ feet. The range of the cod includes the coasts of Northern Europe, Iceland, and Greenland, whence it descends on the American coast as far as the latitude of New York; the depth at which the fish is found extending as low as one hundred and twenty fathoms. In Britain the spawning-time is in January, at which season these fish resort to the shores in great numbers, although at other times of the year they are only found in the neighbourhood of land singly. In America cod do not deposit their spawn till May. The great fisheries are those of the Dogger Bank in the North Sea, Iceland, and the banks of Newfoundland; the product of the latter area having been formerly the greatest of all, its average value some twenty years ago being estimated at upwards of £700,000, of which £400,000 was accounted for by the dried fish alone, the remainder being made up by the oil, skins, etc. The cod is an exceeding productive fish, Buckland stating that the number of eggs in a roe weighing 7¾ lbs. was close on seven millions. Cod feed on various crustaceans, worms, molluscs, and small fish; and since they always frequent comparatively deep water, they are caught by means of lines.

Haddock. Belonging to the same group of the genus as the common cod, the haddock (*G. æglefinus*), which is shown in the left upper figure of the illustration on p. 432, may be always recognised by the blackish patch on each side of the body above the pectoral fin and the black lateral line. Generally haddock vary in weight from ½ to 4 lbs., but in northern seas they attain a larger size than further south, and measure as much as a yard in length. In England the largest haddock are taken in winter, when they resort to the coast for the purpose of spawning. They generally associate in large shoals; and in stormy weather seek shelter in deep water among seaweeds, when it is useless to attempt fishing for them. In addition to crustaceans and other invertebrates, their food comprises small fishes of various kinds. Haddock are largely consumed when split, dried, and smoked. They range across the Atlantic.

Other Species. By far the most delicately flavoured British representatives of the genus is the whiting (*G. merlangus*), shown in the right upper corner of the illustration on p. 432, which differs from all the preceding species in the absence of a barbel on the chin, and is specially distinguished by a black spot near the root of each pectoral fin. The usual weight is about 1½ lbs., 4 lbs. being nearly the maximum attained. The distributional area of the whiting is restricted to the seas of Northern Europe, where it is found in vast shoals; Plymouth being one of the British localities where these fish occur in great abundance. Very shy in its habits, the whiting is a voracious fish, Yarrell stating that several sprats have been taken from the stomach of one, while in another of 4 lbs. weight were found four full-grown pilchards. The same writer states that it appears to prefer sandy banks, but frequently shifts its ground in pursuit of the fry of various other fishes on which it chiefly feeds. Next to the mackerel, the whiting suffers more by transport than any British sea-fish, and should be eaten as soon as possible after capture. Another species with a black spot near the pectoral fin is the pout, or whiting-pout (*G. luscus*), which may be at once distinguished from the whiting by the barbel on the chin, and the greater depth of the body, which during life is marked with dark crossbands. Seldom exceeding 5 lbs. in weight, this fish ranges from Scandinavia to the Mediterranean, but does not cross the Atlantic. The name of pout is derived from the power possessed by this fish of inflating the membranes covering the eyes and adjacent regions into a bladder-like form. Nearly allied is the much smaller power-cod (*G. minutus*), which seldom exceeds half a dozen inches in length, and may be further distinguished by the smaller proportionate depth of the body. Found in vast shoals in the Baltic, the power-cod, although of little or no value, is always welcomed as the harbinger of the advent of its larger cousins. The pollack, or whiting-pollack (*G. pollachius*), is a British representative of the group in which the lower jaw is the longer, and all the upper teeth are of equal size; it has a dark spot near the pectoral fin, but no barbel. This fish is an inhabitant of European seas as far as the western portions of the Mediterranean. Haunting rocky ground, pollack are famous for their power of withstanding strong tides and currents; they are very common in many parts of the south coast of England, as Devonshire, but become scarcer to the north. Being free biters, they afford good sport with the line. The coal-fish (*G. virens*) is a closely allied but somewhat larger form, more northern in its distribution, and taking its name from the black colour it frequently assumes. This fish is very common in the Baltic and other northern seas, numbers being captured in the Orkneys. The largest specimen on record appears to be one mentioned by Buckland, which measured just over 3½ feet in length, and scaled 25 lbs.

Hakes

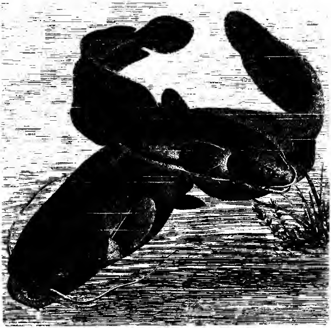
Before referring to this species it may be mentioned that a deep-sea cod (*Halargyreus*), which has been taken off Madeira and New Zealand, belongs to a small group characterised by having two dorsal and two anal fins. On the other hand, the hake (*Merluccius vulgaris*) is the British representative of a genus belonging to a much larger group, characterised by having two dorsals, a single anal, and a separate caudal fin. As a genus, the hakes are distinguished by the strong development of the pelvic fins, which are broad at the base, as well as by the presence of strong teeth on the jaws and vomer, and the absence of a barbel. The common hake is found on both sides of the North Atlantic and other European seas; and is represented in the colder seas of South America, as well as in those of New Zealand, by the allied *M. gayi*. The hakes are peculiar in having the transverse processes of some of the trunk-vertebræ expanded and inflated, so as to form a kind of roof over the air-bladder. In size the common hake is a rather large fish, reaching 2 or even 3 feet in length. On the Cornish coasts, which they frequent in numbers in pursuit of the shoals of pilchards, hake have been taken in vast quantities, upwards of forty thousand having once been landed in a day at Mount's Bay, while on another occasion eleven hundred were taken in two nights by a single boat. When captured in the pilchard-nets, these fish generally gorge themselves to such an extent on their fellow-captives as to become completely helpless. Although the flesh is coarse and of inferior flavour, large numbers of hake are dried and salted.

Burbot

As an example of a fresh-water representative of the cod family, we may refer to the well-known burbot or eel-pout (*Lota vulgaris*), which is the sole member of its genus, and is common in the rivers of Central and Northern Europe and North America. Belonging to the group with two dorsals, one anal, and a distinct caudal, the genus *Lota* has the first dorsal fin well developed, with from ten to thirteen rays, the pelvics with several rays, the head flattened, the body much elongated, and villiform teeth in the jaws and on the vomer. The chin is furnished with a barbel. In length the burbot exceeds a yard, and its flesh ranks high among fresh-water fish. Its form is shown in the uppermost figure of the illustration on p. 436. In Britain found only in the east of England, where it is not uncommon in the Cam and the Ouse, the burbot is widely distributed on the Continent, frequenting alike large rivers, small streams, lakes, and pools. It prefers, however, deep to shallow water, being found in large lakes at a depth of from thirty to forty fathoms; its colour being then paler than is the case with specimens from shallower water. From its habit of lying concealed beneath stones or in holes on the river bank, the burbot in some parts of England is known as the coney-fish. Its food consists of the fry of other fishes, or the adults of the smaller kinds; and it is stated to be particularly destructive to the perch. In the spawning-season, which varies considerably according to localities, burbot are in the habit of congregating in large numbers; and in some of the German rivers masses of these fishes, including as many as a hundred individuals, may be found knotted together after the fashion of eels. While some burbot spawn in November and December, in others the function is delayed till March;

and it is during the spawning-season that the fish is in the best condition for the table. The burbot is a fish of slow growth, not attaining full maturity till it is upwards of four years old.

Ling and Rocklings. Distinguished from the burbot by the presence of several enlarged teeth in the lower jaw and on the vomer, the ling (*Molva vulgaris*) may be regarded merely as a marine representative of that genus. The common



BURBOT AND WELS, immature (¼ nat. size).

ling, which generally measures from 2 to 3 feet in length, is a northern form, ranging from the coasts of Greenland and Iceland to those of Britain and other parts of Northern Europe. In this fish the upper jaw is the longer, but the reverse condition obtains in a second Scandinavian species and also in a third from the Mediterranean, which are the only other representatives of the genus. The ling fishery is an important industry, large quantities of these fish being cured and dried. Belonging to the same group of the family as the ling, the rocklings (*Motella*) are readily distinguished by the reduction of the first of the two dorsal fins to a narrow-rayed fringe, with the first ray elongated, more or less completely received in a longitudinal groove. There is a band of teeth in the jaws, and another on the vomer, and all the species have barbels, not only on the chin but likewise on the muzzle, the number of these appendages affording the readiest means of specific discrimination. They are all of small size, and while ranging over the same seas as the ling, likewise extend to those of Japan, the Cape, and New Zealand. The British representatives of the genus include the five-bearded rockling (*M. mustela*), with four upper barbels, the four-bearded rockling (*M. cimbria*), and the common three-bearded rockling (*M. tricirrhata*); the little fish commonly known as the mackerel-midge, and formerly regarded as the representative of a distinct genus being only the young of the rocklings.

Brief mention may be made here of a fish from the Northern, Temperate, and Arctic seas, known as the torsk (*Brosmius brosme*), on account of its forming the sole representative of a group characterised by having only a single long dorsal and a shorter single anal fin, the caudal being distinct, the narrow pectorals formed of five rays, teeth present on the vomer and palatines, as well as in the jaws, and the chin furnished with a barbel. Attaining a length of a little over 20 inches the torsk is occasionally taken in the Firth of Forth, and is abundant round the Shetlands and Orkneys.

SAND-EELS AND THEIR ALLIES.—Family *OPHIDIIDÆ*

In this rather small family, almost all the members of which are marine, the pelvic fins, if developed at all, are rudimentary; there is no separate anterior dorsal or anterior anal, and the caudal is generally confluent with the median fins. In form the body is more or less elongate, but it may be either naked or scaled. The dorsal fin occupies the greater portion of the back; the rudimentary pelvics are jugular in position; the gill-openings are wide; and the gill-membranes are not attached to the isthmus. While some of these fishes are deep-sea forms, others are littoral. The family may be divided into five subfamily groups.

Cave Fish.

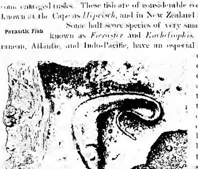
The most remarkable representatives of the first subfamily (in which pelvic fins, attached to the pectoral girdle, are always present) are two small fishes from the subterranean fresh waters of certain caves in Cuba, constituting the genus *Lucifuga*. They are totally blind, with the eyes rudimental and covered with skin or wanting, and always live in perpetual darkness. The cave-fish are closely allied to certain small fishes from the Tropical Atlantic and Indian Oceans forming the genus *Brotula*, and characterised by the elongate body being covered with minute scales, the moderate-sized eyes, the reduction of each pelvic fin to a single filament, of which the extremity may be split, the villiform teeth, and the presence of barbels on the muzzle; these barbels being reduced in the cave-fish to small tubercles. With the exception of these cave-fish, all the members of this family are marine forms; and it is very curious that among the latter there are two very rare species, respectively constituting the genera *Typhlonus* and *Aphyonus*, found at great depths in the southern oceans, which are also completely blind, and apparently unprovided with any phosphorescent organs.

Snake-Fishes.

The typical genus *Ophidium*, constituting with an allied form the second subfamily, has the pelvic fins replaced by a pair of barbel-like filaments; the elongated and compressed body being covered with very minute scales, while the eyes are medium, and the teeth small. The few species of this genus range over the Atlantic and Pacific. In the South American, South African and Australasian seas there occur three much larger but nearly allied fishes, which have been referred to a second genus (*Genypterus*), on account of the outer row of teeth in the jaws as well as those of the single palatine series containing some enlarged tusks. These fish are of considerable commercial importance, and are known at the Cape as *Klipvisch*, and in New Zealand as Cloudy Bay cod, or ling.

Parasitic Fish.

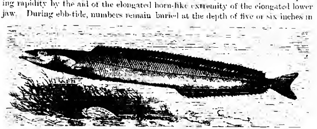
Some half-score species of very small eel-like fishes scientifically known as *Fierasfer* and *Encheliophis*, and inhabiting the Mediterranean, Atlantic, and Indo-Pacific, have an especial interest on account of their curious mode of life. They constitute a subfamily, readily characterised by the total absence of pelvic fins and by the vent being situated at the throat; and are parasitic in other marine animals, frequenting the hollows in the bodies of jelly-fish, the breathing chambers of star-fishes and sea-cucumbers, and sometimes insinuating themselves between the layers of the mantle of pearl-mussels or other bivalve molluscs. Occasionally they may become embedded in the substance of the shell of the pearl-mussel by the deposition of pearly matter over their bodies; an instance of this peculiar mode of preservation being shown in the accompanying illustration.



PARASITIC FISH EMBEDDED IN A PEARL-MUSSEL.
(From Günther, *Proc. Zool. Soc.*, 1886.)

Sand Eels.

The third subfamily is represented by the well-known sand-eels or launces, of which a British species (*Ammodytes tobianus*) is figured in the illustration, so abundant on sandy shores in Europe and North America, as well as by an allied genus from Madras. While agreeing with the preceding group in the want of pelvic fins, they differ in having the vent situated far back in the body; and are further characterised by the great width of the gill-openings, the gill-membranes of opposite sides not being united. The lower jaw exceeds the upper in length, the dorsal fin occupies nearly the whole length of the back, and the anal is likewise elongated. The figured species, which is by far the commoner on the British coasts, generally measures from 5 to 7 inches in length, whereas the greater sand-eel (*A. lanceolatus*) may grow to a foot and a half. Sand-eels feed on marine worms and very small fish; and when buried in the sand are captured in some parts of England by raking the sand with a long-pronged rake; their chief use being for bait. They are, however, by no means restricted to this kind of life frequently swimming near the surface in large shoals, when they will at times suddenly descend to the bottom, where they bury themselves with surprising rapidity by the aid of the elongated horn-like extremity of the elongated lower jaw. During ebb-tide, numbers remain buried at the depth of five or six inches in



LESSER SAND-EEL (⅞ nat. size).

the sand till the next flood; and it is then that they are dug out with rakes or other implements. When swimming, they are followed by shoals of mackerel and porpoises.

Conyrodus The last group of the family is represented by *Conyrodus* of the Australian coasts, and *Haliophis* from the Red Sea, both of which differ from the sand-eels by the narrower gill-openings, and the union of the two gill-membranes beneath the throat.

THE LONG-TAILS.—Family *MACRURIDÆ.*

The fourth family of the symmetrically formed soft-finned fishes is typically represented by the genus *Macrurus*, as well as by several allied forms. These fish are characterised by the body ending in a long, compressed, and tapering tail, covered with spiny, keeled, or striated scales, and unprovided with an expanded fin. There is a separate short first dorsal fin, followed, after a short interval, by a very long and low second dorsal, which is composed of very weak rays, and is continued to the end of the tail; the anal occupying a precisely similar position on the under surface, and the thoracic or jugular pelvic fins consisting of several rays. Dr. Gunther writes that "this family, known a few years ago from a limited number of examples, representing a few species only, proves to be one which is distributed over all oceans, occurring in considerable variety and great abundance at depths of from one hundred and twenty to two thousand six hundred fathoms. They are, in fact, deep-sea gadoids, much resembling each other in the general shape of the body, but differing in the form of the snout, and in the structure of their scales. About forty species are known, many of which attain a length of 3 feet."

THE FLAT-FISHES.—Family *PLEURONECTIDÆ.*

Distinguished by the unsymmetrical conformation of the head and anterior region of the body in the adult, in consequence of which both eyes are brought on to one side of the body (in some cases the right, and in oth[illegible]e left), the flat-fishes differ not only from all other members of their class, but likewise from all other vertebrates. The body is strongly compressed and flattened, with the side which is turned upwards, and on which are situated the eyes, coloured dark, while the opposite or eyeless side is, as a rule, colourless. The bones of the head are unequally developed and unsymmetrical; and the dorsal and anal fins are of great length and undivided, the former often extending forwards so as to separate the blind from the eyed side of the head. In the most specialised forms the teeth and jaws are more developed on the lower or blind side than on the other, and there is no air-bladder. Dr. Cunningham, who has paid special attention to the structure of these fishes, writes that "mere dissection of adult specimens shows that the anomalous position of the eyes is due to a distortion of the facial region of the skull. The cranial region of the skull is but slightly altered, but the interorbital parts of the two frontal bones are bent away from their original position in the dorsal median line down to the side of the head, and they are also compressed into a thin plate. But the eyes have pretty nearly the same relations to the interorbital septum as in an ordinary fish. There is one eye on each side of the septum as usual. It is, in fact, the curious condition of the dorsal fin in the flat-fish, even more than the mere distortion of the eyes, which makes it so different from the ordinary fish. If the fin terminated some distance behind the eyes, or if it was prolonged in the direction it ought to follow, that is along the line which divides the two frontal bones from one another, it would be plain at a glance which was the left side of the head and which the right. It would then be obvious that the left eye was still on the left side of the head, and the right eye on the right. But the dorsal fin does neither of these things. The external ethmoid bone belonging to the blind side is much enlarged, and sends back a process outside the eye belonging to that side to meet another process from the cranial region of the skull. Thus the eye which has migrated—the upper eye when the fish is held in a vertical plane—is enclosed in a complete bony orbit, while the lower eye is merely bounded on its outer side by the jaw muscles. It is on this bony bridge, entirely foreign to the anatomy of an ordinary fish, that the dorsal fin supports itself in its advance towards the snout. Properly speaking the left side of the face in a plaice, for instance, extends from the ventral edge, or chin, to the line between the eyes, but the dorsal fin in its anterior extension divides this side of the face into two parts."

The pigment-bearing elements in the coloration of the dark side of flat-fish are known as chromatophores; and while these are absent from the light side, the so-called silvery layer is present on both. Young flat-fish, which are generally met with in the open sea, are transparent and perfectly symmetrical, with one eye on each side of the head, and swim in the vertical plane like ordinary fishes. That flat-fishes have originated from symmetrical ancestors is quite evident, their individual metamorphosis indicating the manner in which the evolution took place. As to the inducing causes of this evolution and metamorphosis, there is still some difference of opinion; and as it is a subject which does not come within the province of this work it need not be further alluded to. There are, however, certain experiments with regard to the normal absence of coloration on the under surface

of these fish which are of sufficient interest to merit a brief notice. Knowing, as we do, that among plants absence of light leads to the deprivation of colour, it was thought highly probable that the same might be the case with regard to flat-fish, more especially since the absence of coloration in the olm among the Amphibians is clearly due to the same cause. To test this, flounders were kept in a tank, in which, by the help of a mirror, light was so introduced as to give to the fishes the unwonted experience of illumination ascending from below instead of coming down from above. The experiment was conducted for several months; some of the flounders died, in others no great effect was produced, but in some cases the white surface became marked over with pigment. This experiment demonstrates that the capacity for colorisation existed in the skin, but that light was wanted to call it into action; and it may also be inferred that the incidence of light must in general be the reason why the upper surfaces of animals are more strongly pigmented than the lower. Occasionally what are known as 'double flat-fish' are met with, that is specimens in which both sides are coloured, and one eye situated on the edge of the head; such monstrosities having been observed in the turbot, flounder, plaice, sole, etc. In one turbot the right eye was on the edge of the head, so that the dorsal fin, instead of extending as usual, to the front of the head was separated therefrom by a concavity, the right side being coloured like the left, although somewhat less strongly. It has been thought that these 'double-fish' swam about in a vertical position, M. Giard stating that he has actually seen a turbot so doing. But Dr. Cunningham writes that there is "no satisfactory evidence at present that the monstrous specimens, whose metamorphosis is permanently arrested, swim about, in whatever position, any more frequently, or rest on the ground less constantly than their normal brethren. I have under observation a living double specimen of the plaice; its eye is on the edge of the head, the dorsal fin terminates behind the eye, and the posterior three-fourths of the lower side are coloured like the upper, the anterior fourth being white. This specimen, instead of showing a tendency to continue swimming in the water, cannot even be induced to leave the bottom long enough to enable me to see whether it holds itself perfectly horizontal or not. I have never seen it leave the bottom of its own accord; it lies always buried in the sand up to its eyes, and, when disturbed makes violent struggles to bury itself again."

When lying on the sandy bottom of the sea—and they prefer sandy to muddy situations—flat-fish are almost indistinguishable from their inanimate surroundings, the spots with which the bodies of many of them are marked harmonising exactly with the bright-coloured pebbles strewing the sand. This resemblance is, perhaps, carried to the fullest extent in the flounder, as anyone who visits a large aquarium may ascertain for himself. Occasionally rising to the surface, they swim with an undulating lateral movement of the body, which is decidedly graceful; and they are found in shallow water, or at moderate depths. They are inhabitants of all seas except those of the polar regions, and where the coast is precipitous and rocky; and although more numerous in the tropics, they attain their greatest development in point of size in the temperate regions. Many species, such as flounders, ascend rivers to a considerable distance; and a few have become accustomed to a fresh-water existence. As regards food, the whole of the species are exclusively carnivorous. In a fossil state the flat-fish are but poorly represented, and it is probable that they were not evolved till the commencement of the Tertiary period, the earliest known form being a turbot from the middle Eocene of Monte Bolca, while a fossil sole has been described from the Miocene of Würtemberg. As a food-supply the flat-fish are of especial value, not only on account of the large size and abundance of their numerous representatives, but likewise from the excellent quality and flavour of the flesh of the majority of these. It is on the coasts of the temperate regions of the Northern Hemisphere that the pursuit of these fish is carried out with the greatest energy and success.

Psettodes.

The least specialised member of the family (*Psettodes erumei*), which ranges from the Red Sea through the Indian Ocean to China and also occurs on the West Coast of Africa, belongs to a group in which the teeth and jaws are nearly equally developed on both sides, and is specially distinguished by the dorsal fin commencing on the nape of the neck, whereas in all the other forms it starts from above or in front of the eyes. In the Indian fish, which attains a length of about 16 inches, the eyes are as frequently on the right as on the left side, and the transposed one is situated nearly in the line of the dorsal fin. This species is a connecting link between the other members of the family and ordinary fishes, and is reported to swim at times in a vertical position.

Holibut.

Having the jaws nearly equally developed on both sides, and the dorsal fin commencing above the eyes, the holibut (*Hippoglossus vulgaris*) is one of two species forming a genus characterised by the eyes being on the right side, and the teeth of the upper jaw arranged in a double series, those in the front of the upper and on the sides of the lower jaw being enlarged. The mouth is relatively wide. In colour the holibut is dusky brown, frequently inclining to olive on the dark side; the opposite side being white and smooth. It is the largest member of the family, ranging usually from 3 to 6 feet in length, one specimen with the latter length having a breadth of 30 inches, and a weight of 161 lbs. It is stated, however, that an example taken in the early part of this century off the Isle of Man was nearly double that weight. Holibut are found near all the northern coasts of Europe, as well as those of Kamschatka and California, generally frequenting banks at some distance from the shore in water of from fifty to one hundred fathoms in depth, where they often associate in considerable numbers. The flesh is coarse, and of inferior flavour. This fish is shown in the upper figure of the coloured Plate.

Turbot, etc.

In the genus typically represented by the turbot (*Rhombus maximus*) the dorsal fin commences on the muzzle in advance of the eyes; the eyes are on the left side; the mouth is wide; and the jaws are furnished with a single series of equal-sized villiform teeth, while there are also teeth on the vomer. Scales are either very small or wanting. The genus includes seven species, ranging over the North Atlantic and Mediterranean, but those on the two sides of the Atlantic are different. The turbot, which attains a yard in length, and is by far the best food-fish of its tribe, is exclusively European, and has the pelvic fins distinct from the anal, and no scales; the general colour being greyish or brownish, sometimes spotted with a darker tint. On the other hand the brill (*Rh. laevis*), which is likewise European, is a smaller fish of more oval shape, with the body and all the head, except the muzzle, covered with minute scales; its colour being greyish brown, with reddish brown spots. Turbot commonly weigh from 5 to 10 lbs., and occasionally reach 20 or even 30, while considerably greater weights have been recorded. Another British representative of the genus is the Mary-sole (*Rh. aquosus*), which may be distinguished by its ciliated scales; while a fourth, known as Block's top-knot (*Rh. punctatus*), differs from all the foregoing by having the pelvic fins confluent with the anal. The true top-knot (*Phrynorhombus unimaculatus*), which is a small form not uncommon on the southern coasts of England, and abundant in the Mediterranean, is referred to a distinct genus on account of the absence of vomerine teeth. A turbot is shown in the central figure of the coloured Plate.

Plaice and Flounder. The plaice (*Pleuronectes platessa*) and flounder (*Pl. flesus*), of which examples are shown in the right lower corner of the coloured Plate, are examples of a genus pertaining to a group characterised by the narrowness of the cleft of the mouth, and by the jaws and teeth being much more developed on the light than on the dark side. Unlike the turbot and its allies, where the upper is somewhat behind the lower, the two eyes are in the same transverse line, and generally situated on the right side. The dorsal fin commences above the eyes; the scales are minute or wanting; and there are no teeth on the palate, while those in the jaws are of medium size, and may be arranged in either a double or a single row. The genus, which is common to the Northern, Temperate, and Arctic seas of both hemispheres, contains over a score of species, which may be divided into groups according to the form of the teeth, the number of rays in the dorsal fin, and the conformation of the lateral line. The plaice, which ranges from the French coasts to Iceland, and is represented by an allied form on the opposite side of the Atlantic, belongs to a group with compressed lanceolate or truncate teeth, and no fewer than ninety dorsal rays; it has the brownish upper surface marked with bright yellow spots. This species is exclusively marine, but the flounder is almost as much a fresh-water as a sea fish, ascending rivers to a considerable distance. Distinguished from the plaice by the dark mottlings on the brownish or brownish yellow skin of the upper surface, it belongs to a group in which the teeth are conical, the lateral line being very slightly curved in front, and the scales minute. Its distribution is practically the same as that of the plaice, and it is represented by an allied species in the Mediterranean.

Soles. In the plaice and its allies the pectoral fins are always well developed, but in the group to which the common sole (*Solea vulgaris*) belongs these may be wanting, while the upper eye is always somewhat in advance of the lower one, both being on the right side. As a genus the numerous species of soles (somewhere about forty in number) are characterised by the median fins being separate from one another, and the ctenoid scales; the dorsal fin commencing on the muzzle, and the lateral line being straight. The cleft of the mouth is very narrow, and twisted round to the left, or blind side; and it is on this side only that villiform teeth are developed in the jaws, the palate being toothless. With the exception of the lower south temperate zone, soles are distributed over all temperate and tropical coasts in localities suited to their habits; many of the species entering, or even dwelling permanently in fresh waters. The common sole, which is found on the coasts of the greater part of Europe, has both pectoral fins well developed, and the nostrils of the blind side very narrow; the general colour being dark brown, with the tips of the pectoral fins blackish. Large specimens may weigh as much as 5 or 6 lbs., and a fish of 9 lbs. in weight is on record. Soles are taken by trawling; the best ground in England being along the south coast from Dover to Devonshire. The lemon-sole (*S. aurantiaca*), which is a more southern form, ranging from the south of England to Portugal, and living in deeper water, is one of a group characterised by one of the nostrils of the blind side being dilated and surrounded with a fringe of papillæ. It is smaller and wider than the common species, and orange or light brown in colour, dotted over with numerous small brown spots. Other British species are the banded sole (*S. variegata*) and the dwarf sole (*S. minuta*), both belonging to a group characterised by the small size of the pectoral fins. The Mediterranean sole (*S. monochir*) is peculiar in lacking a pectoral fin on the blind side; while the Japanese sole (*S. japonica*) is one of two species in which both these fins are absent. The common species is shown in the left lower corner of the coloured Plate.

Blind Soles. On account of the rudimentary condition of their eyes we must not omit mention of the blind soles, which are divided into two genera, the one (*Soleotalpa*) characterised by the separation of the median fins, which are confluent in the other (*Apionichthys*); pectoral fins being wanting in both. Each genus is represented only by a single species; *Soleotalpa* coming from the West Indies, while the habitat of the other species appears to be unknown.

THE TUBE-BLADDERED FISHES,—Suborder PHYSOSTOMI.

It has been already stated on p. 334 that the whole of the four preceding subordinal groups of the bony fishes are regarded by Professor Cope as constituting but a single suborder (Physoclysti) characterised by the absence of a duct to the air-bladder, the separation of the parietal bones of the skull by the supraoccipital, and by the pelvic fins being usually thoracic or jugular in position. The group to which we now come, including the whole of the remaining representatives of the existing bony fishes, differs from the above in that the air-bladder, when present, has a duct communicating with the stomach or œsophagus, while the pelvic fins are always abdominal in position, and the parietal bones are usually in contact with each other. With regard to the constancy and importance of these characters of the present suborder, Professor Cope writes that the presence of the duct from the air-bladder which characterises it, "is always associated with an abdominal position of the pelvic fins and cycloid scales, and mostly with the presence of the precoracoid arch, the entrance of the maxillary bone into the border of the mouth, and the non-separation of the parietal bones by the supraoccipital. Yet none of these characters are precisely associated at the point of change in each, for there are Physostomous fishes with separated parietals and ctenoid scales (some *Cyprinodontidæ*), and there are Physoclysti with abdominal pelvic fins." In the present suborder, with the exception of the first in the dorsal and pectorals, which may be ossified into spines, all the fin-rays are soft and jointed. Very different views obtain as to the best mode of arranging the families constituting the suborder, and a final classification is still a desideratum. By Professor Cope the families have been arranged in a number of sectional groups, mainly distinguished by the structure of the skeleton; and a modification of this arrangement is adopted here, although fewer groups are recognised. It is, however, impossible to enter here into the consideration of the osteological features by which these sections are distinguished, and we are accordingly compelled to rely mainly on external characters.

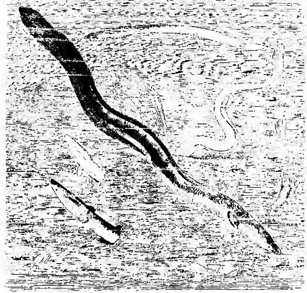
THE EELS AND THEIR ALLIES.—Families *MURÆNIDÆ*, *SYMBRANCHIDÆ*, and *GYMNOTIDÆ*

The whole of the members of these three families are characterised by the elongated, "eel-like" form of the body; but it is quite probable that this external similarity is due to parallelism in development, and that the three families have been independently derived from very different types of more normally formed fishes. The first family, which includes the true eels, murænas, and congers, is characterised by the normal structure of the upper jaw, which is formed in front by the premaxillæ (more or less confluent with the vomer and ethmoid) and laterally by the toothed maxillæ. The median fins, when present, are either confluent or separated by the projecting tail; the pectorals may or may not be developed; but the pelvic pair is invariably wanting. There are no accessory breathing-organs; the stomach has a blind appendage; the vent is generally situated far back, but may be near the pectoral fins; and the ovaries have no ducts. Externally the skin may be either completely naked, or may contain rudimental scales. In the skeleton the pectoral arch is unconnected with the skull, and attached to one of the earlier vertebræ. Eels are found in the fresh waters and seas of the greater part of the temperate and tropical regions; some living at abyssal depths in the ocean. The young of some forms are pelagic for a portion of their existence, and it is believed that a large number of the so-called Leptocephali (see p. 322), or glass-eels, are abnormal larvæ of this family. Geologically the family is a comparatively ancient one, true eels having been discovered in the Chalk of the Lebanon, as well as in the Tertiaries of Europe. Congers referred to the existing genus *Ophichthys* have been described from the middle Eocene of Monte Bolca, and there is also an extinct genus from the latter deposits, and a second from the London Clay.

Murænas. The murænas are large marine eels, remarkable for their bright spotted or mottled coloration, and taking their name from the species here figured (*Muræna helena*), which was so called by the ancient Romans. Belonging to a small section of the family characterised by the gill-openings into the pharynx being in the form of narrow slits, they are specially distinguished by the median fins being well developed, and the total absence of pectorals. The skin is scaleless; the mouth is well furnished with teeth; and there are two nostrils on each side of the muzzle, the front pair being tubular, while the hinder ones may be either tube-like or mere flat openings. The murænas, of which there are more than eighty species, are distributed over all tropical and temperate seas, and a few ascend tidal rivers. The majority of them are armed with formidable teeth—which frequently alter considerably with age—adapted for seizing the fish on which they feed. "Large specimens thus armed," writes Dr Günther, "readily attack persons in and out of the water; and as some species attain a length of 6 or 8 feet, they are justly feared by fishermen." The minority of species have obtuse and molar-like teeth, their food consisting chiefly of crustaceans and other hard-shelled animals. "Most of the murænas are beautifully coloured and spotted, some in a regular and constant manner, whilst in others the pattern varies in a most irregular fashion; they have quite the appearance of snakes." The figured species, which ranges from the Mediterranean to the Indian Ocean and Australia, has the ground-colour a rich brown, upon which are large yellowish spots, each dotted with smaller spots of brown. The finless murænas (*Gymnomuræna*), of which half a dozen species have been described from the Indian and Pacific Oceans, differ in the reduction of the fins to a rudiment near the end of the tail.

MEDITERRANEAN MURÆNA ([illegible] nat. size)

True Eels The typical eels, familiar to all in the form of the common European species (*Anguilla vulgaris*) agree with the great majority of the family in having the gill-openings into the pharynx as wide slits. The skin contains small scales embedded in its substance; the upper jaw does not project beyond the lower; the small teeth are arranged in bands; the narrow external gill-openings are situated at the base of the well-developed pectoral fins; and the dorsal fin commences at a considerable distance behind the back of the head. Eels, of which there are numerous species, appear to be distributed throughout the fresh waters of the habitable portions of the globe, being reputed to be absent only from those of the Arctic regions, and probably also from cold elevated districts like Turkestan and Tibet. The common European eel is spread over the greater part of Europe and the Mediterranean area—although unknown in the Danube—and reappears in the United States. The so-called **grig** or glut eel, characterised by its lighter colour, broader head, and snout and the more backward position of the front of the dorsal fin, has been generally regarded as a distinct species, although this is not admitted by Day. About a yard is a good size for an eel, although much longer specimens are on record. Few subjects have given rise to more discussion than the mode of propagation of eels, and as this must be noticed in some detail, we take the following extracts from a paper published a few years ago by the last-named observer. After mentioning the difficulties that



EELS IN THE MUD (⅛ nat. size).

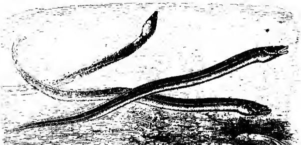
took place in the identification of female eels, the author states that when this point was cleared up, naturalists became rather puzzled where to look for the male element, so the idea took root that these fishes might be hermaphrodites. It was observed that in addition to the frill-shaped band forming the undoubted ovaries, there was a second fatty band running along one side of the intestines, in which milt was erroneously stated to have been discovered. In 1873, however, an organ was discovered in an eel of 16 inches in length, which was correctly identified with the male element, since which date numerous males, which are generally of smaller size than the females, have been recognised. "For the generation of eels it would seem, so far as we are at present aware, that the presence of salt water is a necessity, for it has been observed that when these fish leave rivers and brackish waters for the sea, their reproductive organs have scarcely begun to develop. But their maturing in the sea must be rapid, because in five or six weeks they have arrived at a breeding condition. This rapidity of maturing in the breeding-organs would seem to be the cause of extreme exhaustion. Consequently, after the breeding-season is over, eels die, similarly to lampreys and several other piscine forms; and this furnishes the explanation why, subsequent to this period, old eels are not observed reascending rivers." After describing the appearances of the reproductive organs in fully-developed eels of both sexes, as well as those of sterile individuals, Day observes that "it becomes necessary to allude to the localities in which each of these forms may be found. Here, again, imagination seems to have mixed up fact with fiction, and it has been maintained that should very young eels be introduced from the mouths of rivers into inland pieces of water, they invariably develop into fish of the female sex, as it was supposed males were never to be seen in fresh water. Whether such waters are really conducive to the destruction of young male eels, appears to be a subject requiring further elucidation. The female eels are those usually captured when descending towards the mouths of rivers during the autumn months, while such as are developing towards a breeding condition do not seem to feed at these periods. Males have been usually obtained from the mouths of rivers or in brackish waters, and Dr. Paul, having discovered that among elvers or young eels captured in such localities were males, ascertained (at least so he asserts) that when transported to fresh waters, they retained their masculine character, developing into adults. Some have been captured ten or twelve miles up rivers; but, although male eels undoubtedly ascend rivers, their proportionate number to that of females decreases in accordance to the distance from the sea. Sterile eels are found in fresh waters, and likewise in those which are brackish, where they may often be captured feeding, but these fish, of course, cannot increase in numbers unless they have access to the sea, and consequently above impassable barriers they die out, should no young be introduced. The migrations of these fishes may be said to be two annually, adults descending seawards to breed, as they do in the Severn about the month of September, although this migration in Norfolk is asserted to begin as early as July. There is likewise an up-stream migration of young eels or elvers, in the earlier months of the year up to May or June, or even later, during this period the banks of the rivers being in places black with these migrating little fishes. These young eels have been observed to ascend floodgates of locks, to creep up water pipes or drains; in short, mechanical difficulties scarcely obstruct them, and they will even make a circuit over a wet piece of ground in order to attain a desirable spot." In order to give some idea of the vast numbers of young eels that take part in these migrations, or, as they are popularly called "eel-fares," it may be mentioned that upwards of three tons of elvers were dispatched in a single day from the Gloucester district in the spring of 1886, and that it has been calculated that over fourteen thousand of these fish go to make a pound weight. In the previous year the annual consumption of eels was estimated at a minimum 1650 tons, with a total value of £130,000. It is almost superfluous to mention that eels pass the greater portion of their time when in fresh water buried in the mud, from which they issue forth at night to feed. During the cold of winter large masses of them are not unfrequently found tightly coiled together for the sake of mutual warmth. The largest species occur in the islands of the South Pacific and New Zealand, where they inhabit lakes; specimens from these regions having been recorded to measure from 8 to 10 feet in length.

Congers. Resembling the true eels in the presence of pectoral fins, in the tail being surrounded by the median fin, and the free tongue, the gigantic marine forms known as congers differ in being scaleless, in the deep cleft of the mouth, in the presence of a set of teeth on the outer sides of the jaw placed so close to one another as to form a cutting edge, and by the dorsal fin commencing at a point just behind the base of the pectorals. The common conger (*Conger vulgaris*), which may grow to a length of 8 feet, appears to be almost cosmopolitan in distribution, being as abundant in the seas of Tasmania as it is in British waters. Congers feed chiefly by night, and prey upon crustaceans, cuttles, and various kinds of fish, such as pilchards and herrings. Their favourite resorts are either hollows or crevices in the rocks, or sandy bottoms, in which they can bury themselves; and in such situations they are sometimes left by the ebbing tide. The flesh of these eels is of a highly gelatinous nature, and is said to be largely employed in soups. Three other species of the genus are known, one of which is abundant in the Indian Ocean.

Serpent Eels Among the numerous other generic modifications of the family, we select for notice the serpent-eels (*Ophichthys*) as an example of a group in which the extremity of the tail is free, the nostrils are situated at the extremity of the muzzle, and the tongue is fixed. Teeth are present on the vomers, those in the jaws being either obtuse, or pointed and arranged in a single series; and whereas small pectoral fins are present in some species, in others they are wanting. Serpent-eels are represented by a great number of species ranging over all tropical and subtropical seas, but none attaining any large size. The difference in the structure of the teeth of the various species may probably be taken as indicative of a difference in the nature of the food similar to that already recorded as obtaining among the muraenas.

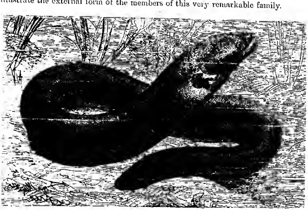
Deep Sea Eels Only a few words can be devoted to the deep-sea members of the family, which are represented by several genera. Among these are certain congers (*Synaphobranchus*) occurring in all oceans at depths of from three hundred and forty to two thousand fathoms, and characterised by the gill-openings being united into a single longitudinal slit on the under surface of the body between the pectoral fins, the gape being very wide, the teeth small, and the body scaled. In these forms the muscular system is well developed; but in another genus (*Saccopharynx*) it is extremely feeble, except on the head, and the bones are soft and spongy. The head and gape are of immense size; the muzzle is short and flexible; the weak jaws are armed with long, slender curved teeth, placed at intervals; and the gill-openings are wide and situated on the lower part of the sides at some distance from the head, the narrow gills being free and exposed. The long and band-like tail ends in a long tapering filament, and the dorsal and anal fins are rudimental. As in the last genus, the stomach is capable of great distention, and specimens which had swallowed fish of many times their own weight have been found floating in the Atlantic with this organ dilated to its utmost. In a third type (*Nemichthys*), from depths between five hundred and two thousand fathoms in the Atlantic, the exceedingly elongate body is band-shaped, with the tail tapering to a point, and the jaws produced into a long slender beak.

Single Slit Eels. It has been already noticed that in one of the deep-sea eels the gill-openings are confluent into a longitudinal slit on the under surface of the body; and a very similar condition characterises the second family (*Symbranchidæ*) of eels only in this case the slit is transverse. A better distinction is, however, afforded by the structure of the upper jaw, the margin of which in the present family is formed entirely by the premaxillæ, on the inner side of which lie the maxillæ. The paired fins are rudimental, and the vertical ones wanting: while the scales, if present, are minute; and accessory breathing-organs may be developed. An air-bladder is wanting, the stomach has no blind appendage, and the ovaries are furnished with ducts; the vent being situated far behind the head. Whereas the majority of these eels inhabit fresh and brackish waters in tropical Asia and America, they are also represented in Australia, where one genus is marine. Of the fresh-water forms, the most remarkable is the amphibious eel (*Amphipnous cuchia*) of Bengal, in which there is an accessory breathing-apparatus, the body is scaled, and the pectoral girdle is detached from the skull. There are only three gill-arches with rudimentary laminæ, separated from one another by narrow slits: and the additional breathing-organ takes the form of a lung-like sac on each side of the neck communicating with the gill-chamber. Day states that "this amphibious fish, when kept in an aquarium, may be observed constantly rising to the surface for the purpose of respiring atmospheric air direct. It usually remains with the snout close to the surface, and in like manner lies in the grassy sides of ponds and stagnant pieces of water, so that



BENGAL SHORT-TAILED EEL (⅓ nat. size).

without trouble it may obtain access to air." Indeed, the chief respiration of this fish is carried on by means of the two sacs on the sides of the neck, which can be inflated and emptied at will. In the other two fresh-water genera, one of which (*Monopterus*) is confined to the Oriental region, while the other (*Symbranchus*) has a distribution coextensive with that of the family, there is no additional breathing organ, the body is naked, and the pectoral girdle is attached to the skull. Whereas in the former of these genera the gills are rudimental in the latter they are well developed: and, in the absence of an accessory apparatus, it seems strange how the one species with rudimental gills manages to breath at all. The Bengal short-tailed eel (*Symbranchus bengalensis*) has been selected to illustrate the external form of the members of this very remarkable family.



ELECTRIC EEL (⅛ nat. size).

Electric Eel. Together with four other genera from the fresh waters of Tropical America, the well-known electric eel (*Gymnotus electricus*) constitutes the third and last family of the group under consideration, the leading characteristics of which are as follows. The jaws are formed in the same manner as in the true eels, and the head is scaleless and without barbels. The dorsal fin is either totally wanting, or reduced to a fatty rudiment; the anal is extremely elongated; pelvics are wanting; and the caudal is likewise generally absent, the tail terminating in a point, which, when broken off, can be renewed in the same manner as in the blind-worms. The vent is situated in or near the throat; the gill-openings are rather narrow: an air-bladder is present; the stomach has a blind appendage; and the ovaries are provided with ducts. In the skeleton the pectoral girdle is attached to the skull. By Professor Cope the typical genus is considered to be to a certain extent intermediate between the last family and the eel-like representatives of the cat-fishes.

As a genus, the electric eel is characterised by the absence of the caudal and dorsal fins, by the anal extending to the extremity of the tail, the absence of scales, the single series of conical teeth, and the minute eyes. Abundant in the rivers and lagoons of certain parts of Brazil and the Guianas, the electric eel grows to a length of fully 6 feet, and is capable of giving a more powerful shock than any of the other fishes endued with electric power. It will be unnecessary to give any description of the electric organs here; and it will accordingly suffice to mention that they form two pairs of longitudinal structures lying between the skin and the muscles; one pair being situated on the back of the tail, and the other along the sides of the base of the anal fin. That these organs are capable of giving shocks sufficient to kill other fish and small mammals is undoubted; but Dr. Günther considers that the description by Humboldt of the capture of electric eels by horses driven into water, in order to receive the shocks and thus exhaust the fishes, seems to be the result of the imagination of some person who related the supposed incident, or to rest on some isolated incident, since no recent travellers to the district have found evidence of the existence of the practice.

SECTION NEMATOGNATHI.

THE CAT-FISHES OR SHEATH-FISHES.—Family *SILURIDÆ.*

Although represented only by a single European species, and that confined to the rivers to the eastward of the Rhine, the great family of cat-fishes is one of extreme importance in tropical and subtropical countries, its members being extremely abundant in the fresh waters and estuaries of the Oriental region, as they are in those of South America. An essential characteristic of the family is the invariable absence of scales, the skin being either smooth or covered with bony tubercles or plates; and this character, together with the presence of the barbels from which they derive their popular title, will always serve to distinguish the cat-fishes from the other great fresh-water family of the carps. In the skull an essential feature is the absence of a suboperculur element to the gill-cover; while the margin of the upper jaw is formed mainly by the premaxillæ, the maxillæ being more or less rudimental. A rayed dorsal fin may be absent, but the fatty dorsal is generally present; and when an air-bladder is developed, it may be either free in the abdominal cavity or enclosed in bone, but always communicates with the ear by the intervention of the auditory ossicles, which are somewhat lenticular in form. The skull is characterised by the full ossification of its lateral region, the septum between the eyes being also bony; and in many instances the skull is prolonged backwards by the development of a kind of bony helmet over the nape of the neck, formed by dermal ossifications overlying some of the bones of the pectoral girdle. Frequently this shield, as well as the hinder bones of the skull, are ornamented with a tuberculated sculpture. Many of these fishes have also a powerful spine at the front of the dorsal fin, which can be locked into a fixed, erect position by a rudimental spine acting as a kind of bolt at its base, and is itself articulated to the vertebræ and also joined by a ring to a second spine, in a manner similar to that obtaining in the angler-fish. To support this spine certain special modifications exist in the structure of the pectoral girdle. Some of the genera, such as the one represented by the eel-like cat-fish, have additional breathing-organs; in this particular instance taking the form of a branched structure attached to the gills. On the other hand, in the sac-gilled cat-fishes (*Saccobranchus*), there is a long sac running down the muscles of the back behind the proper gill-chamber. Through this breathing-sac blood is carried from and returned directly to the heart; and in consequence of this arrangement these fishes can remain alive for hours or even days apart from water, so that they are able to traverse spaces where aquatic respiration is impracticable. Among the Indian representatives of the family it is somewhat curious that whereas most of the forms dwelling far in the interior of the country near and in the hills have the air-bladder ossified, this is not the case with those inhabiting the rivers of the plains and the sea. The majority of the cat fishes are inhabitants of the fresh waters and estuaries of the tropical and subtropical regions of the globe; but, as we have seen, one species is found in those of Eastern Europe, while a considerable number enter the sea, although generally keeping near the coasts. They are found not only in rivers, but likewise in lagoons and marshes. Day writes that "they mostly prefer muddy to clear water, and the more developed the barbels the more these fishes appear to be adapted for an inland or muddy fresh-water residence. The wider and deeper the rivers, the more suited they are for the *Siluridæ*, consequently the larger forms are comparatively rare in the south of India, whilst they abound in the Indus, Jumna, and Ganges, as also in the Irawadi and other Burmese rivers." It may be added that they are equally common in the muddy waters of the La Plata River. "Owing to their usual resort," continues the same writer, "these fishes appear to employ their feelers in moving about in muddy places, and consequently have less use for their eyes than forms that reside in clear pieces of water. This is one reason why the size of the eye as compared with the length of the head is much greater in the young than in the adult. The eye, in fact atrophies, instead of increasing in size in proportion with the remainder of the head. In some species the skin of the head passes over the eye without any trace of a free orbital margin. In the genus *Arius*, and some allied marine forms, the males appear to carry their ova in their mouths, perhaps until the young are produced. Many of these fishes are credited with causing poisonous wounds, and we frequently find such cases admitted into hospitals. The injuries may be divided into two classes, namely, those in which the wounds are of a distinctly venomous description, and those in which the jagged spines occasion intense inflammation, often of a dangerous character." The flesh of the cat-fishes is of an inferior quality, and generally eaten only by the lower classes. All the members of the family are very tenacious of life, and extremely difficult to kill. Geologically cat-fishes date from the lower Eocene London Clay, where they are represented by the extinct *Bucklandium*, apparently allied to an existing African genus, while in the higher Eocene of the south of England there occur species referred to the existing genus *Arius*. An extinct genus has also been described from the Eocene of North America; and in the Eocene of Sumatra, as well as in the Pliocene of India, the fossil forms belong to existing genera, and some of those from the latter deposits even to species still inhabiting the same country. Numerically the cat-fishes form an exceedingly large family, the existing types constituting considerably over a hundred genera, a group of which contains several hundred species. In this work only a very few of them can be even mentioned, some of those selected including the largest members of the family.

Indian Cat-Fish.

Clarias magur is a well-known representative of the first subfamily, in which the long dorsal and anal fins extend nearly throughout the length of the trunk. It belongs to a minor group confined to Africa and the Oriental region, and characterised by the dorsal fin being either composed of jointed rays throughout its length, or with its hinder portion modified into a fatty fin.

Wels.

The wels (*Silurus glanis*), shown in the larger figure of the illustration on p. 436, is the typical representative of the second subfamily, in which the rayed dorsal fin is but little developed, and if present at all occupies only the hinder region of the trunk, the fatty portion being small or wanting. The anal fin is not much shorter than the caudal region of the backbone, and the pelvic fins are behind or below the dorsal. In the wels and its congeners the short dorsal has no pungent spine; the fatty fin is wanting; there are two upper and two or four lower barbels; the head and body are naked; and the tail-fin is rounded. The wels itself, which is confined to the European rivers eastwards of the Rhine, has six barbels, of which the upper pair are considerably longer than the head, and commonly attains a length of from 6 to 9 feet, although it occasionally grows to 13 feet. In colour the head, back, and edges of the fins are bluish black, the sides greenish black spotted with olive-green, and the under-parts reddish or yellowish white with blackish marblings. Frequenting rivers and lakes with muddy bottoms, the wels feed on fishes, frogs, and crustaceans, but it will also seize and pull down ducks, geese, or other birds swimming on the surface. The spawning-time is in the middle of summer, when these fish resort to the shallows in order to deposit their eggs on the stems and leaves of water-plants.

Yarrell's Cat-Fish, etc.

Another gigantic species is Yarrell's cat-fish (*Bagarius yarrelli*), from the large rivers and estuaries of India and Java, which attains a length of fully 6 feet, and from its huge head and mouth is one of the ugliest fishes in existence. The only member of its genus, it belongs to a subfamily in which the rayed dorsal fin is short, and situated in the hinder part of the body in advance of the pelvics; and there is always a fatty fin, which may, however, be short; and the anal is shorter than the caudal region of the backbone. When nasal barbels are developed, they belong to the hinder nostrils. In the group of genera to which Yarrell's cat-fish belongs the front and hinder nostrils are placed near together, with a barbel between them; and in this particular form there are eight barbels, and the upper surface of the head is naked. This gigantic species is of especial interest on account of its fossilised remains occurring in the Pliocene deposits of the Siwalik Hills in North-Eastern India.

The well-known genus *Arius*, from all the tropical regions of the world, belongs to another group of the same subfamily, in which the front and hinder nostrils are close together, but have no barbel, although the hinder pair are provided with a valve. The Tropical American genus *Pimelodus* is the typical representative of a third group of the same subfamily, in which the two pairs of nostrils are equally devoid of barbels, but are placed at a considerable distance apart. The largest species is the leopard cat-fish, or suravi (*P. pati*), from the rivers of Argentina and Uruguay, growing to a length of 6 or 7 feet, and having the yellowish skin marked with a number of black spots, like a hunting-leopard. Somewhat curiously, this genus is represented by two outlying species from West Africa. The best known representative of the fourth and last group of genera in this subfamily is the bayad (*Bagrus bayad*) of the Nile; the group being easily recognised by the circumstance that while the two pairs of nostrils are remote from one another, the hinder have barbels. Both species are confined to the Nile, but the allied *Chrysichthys* ranges all over Tropical Africa, and *Macrones* and *Rita* are Oriental forms. In these forms the short dorsal fin has a pungent spine, and the head and neck are generally protected by a tuberculated bony shield.

Electric Cat Fishes On account of the property from which they derive their name brief mention must be made of the electric cat-fishes (*Malapterurus*) of Tropical Africa belonging to a subfamily in which the rayed dorsal fin, when present, is short and confined to the hinder region of the body, while the pelvic fins are inserted behind. From their allies these fishes are distinguished by the total absence of the rayed dorsal, so that they have only a fatty dorsal immediately in front of the tail (which is rounded), and opposite the anal. The head and body are smooth, the pectoral fins have no spine, and there are six barbels. The species inhabiting the Nile grows to about 4 feet in length.

Mailed Cat-Fishes. The only other members of the family, which space admits of mentioning, are the mailed cat-fishes (*Callichthys*, *Loricaria*, etc.), constituting a subfamily mainly confined to Tropical and South America, although represented by a few Oriental forms. In all these fishes there is always a rather short rayed dorsal fin, beneath or in front of which the pelvics are generally inserted. The gill-membranes are confluent with the skin of the isthmus, and the gill-openings constricted to small slits. The pectoral and pelvic fins are placed horizontally; and the vent is in front of, or only slightly behind, the middle of the length of the body. Among these fishes the species of the genus *Callichthys*, which are confined to the rivers on the Atlantic side of South America, belong to a group characterised by the nearness of the two pairs of nostrils, between which there is generally a short flap, and by the expansion and reversion of the lower lip to form a broad flap more or less deeply notched in the middle. In the genus mentioned, the head is covered with bony plates and the body encased in two rows of transversely elongated overlapping shields on each side; all the species being of small size. Like certain other South American forms belonging to another subfamily, of which the members of the genus *Doras* are perhaps the best known, these mailed cat-fishes are in the habit of making nocturnal journeys during the hot season, when the pond they inhabit is about to dry up to another of greater capacity, and they likewise construct nests for their eggs. In the case of the genus last mentioned, these journeys may occupy several nights, during which the fish travel in large companies. As they have no special breathing sacs they must apparently close their gill-openings, and thus keep the gills moist. The nests, which are made at the beginning of the rainy season, are formed of leaves, beneath which the eggs are deposited and watched over by both parents; the whole structure being sometimes placed in a hole on the margin of the river or pond.

In the armoured cat-fish forming the genus *Loricaria*, the body is remarkable for its elongated and slender form; while the head is depressed, with a more or less produced and spatulate snout, on the under surface of which the mouth is situated at a considerable distance from the extremity, its margins being surrounded by large folds, and each corner having a barbel. Both the dorsal and anal fins are short and elevated, and the entire head and body enveloped in a bony cuirass.

SECTION PLECTISPONDYLI.

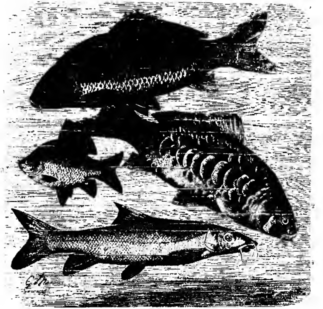
The Carp Tribe,—Family *CYPRINIDÆ*.

Adopting a modification of Professor Cope's classification, the eels and their allies may be regarded as forming one sectional group of the suborder, while the cat-fishes constitute a second by themselves. A third equivalent group will then be made by the carps, together with the under-mentioned family of the characinoids and certain allied forms. This third group—for which the name Plectispondyli has been proposed—while agreeing with the cat-fishes (forming the group Nematognathi) in having the first four vertebræ fused together and highly modified, differs in the presence of a subopercular bone. As in the last family, the margin of the upper jaw is formed by the premaxillæ, and the whole mouth is toothless, teeth being developed on the pharyngeal bones alone. While the head is invariably naked, the body is generally covered with scales, and although it may be scaleless it is never invested with bony plates. False gills may be developed, and, if so, are glandular. When an air-bladder is present it is always of large size; and it may be divided into two lateral moieties enclosed in an ossified capsule, or constricted into an anterior and posterior portion which are not thus protected. The numerous members of this family are fresh-water fish, confined to the Old World and North America, being quite unknown in the southern half of the New World, and also in Australia. Showing much less diversity of form and habits than the cat-fishes, the carp tribe are for the most part omnivorous, although a few of its members restrict themselves to a vegetable diet. Although some of them prefer muddy situations, where their barbels are probably of assistance, the majority of the carps differ from the cat-fish in selecting clear waters for their haunts. The Indian forms seem to be more carnivorous than their European relatives, many of the larger kinds preying upon their smaller brethren. Geologically, the carps appear to be a comparatively modern group, the earliest known forms occurring in the Eocene of Sumatra; these being identified with existing Oriental genera. Other fossil carps have been obtained from the North American Eocene, and are assigned to extinct generic types; while in the Continental Miocene we find representatives of a number of the existing European genera, as well as of a few now mainly or exclusively Asiatic. On account of their more cleanly feeding-habits the flesh of the carps is superior to that of the cat-fishes. The family is represented by over a hundred existing genera, arranged under two subfamilies.

True Carps. The common carp (*Cyprinus carpio*) claims our attention as the typical representative of the subfamily *Cyprininæ*, characterised by the air-bladder (wanting in one Oriental genus) not being enclosed in bone, and divided into an anterior and posterior moiety. In the Oriental genus (*Homalop-*

terus) without an air-bladder the number of barbels is six, but otherwise there are never more than four of these appendages, which may be reduced to a single pair, or be wanting.

Belonging to a group in which the anal fin is short and usually furnished with five or six branched rays, the true carps have the lateral line running along the middle of the tail, the dorsal fin placed opposite the pelvics, and containing a more or less strongly serrated bony ray, and more than nine branched rays, while the pharyngeal teeth are arranged in three series, with those of the outermost one molar-like. The muzzle is rounded and blunt, with four barbels and the rather narrow mouth at its extremity. The true carps form a small genus confined to the temperate parts of Europe and Asia, the common species being a native of the latter continent, and abundant in a wild state in China, where it has also long been domesticated. Thence it was introduced into Germany and Sweden and subse-



GROUP OF CARP.

1. Carp; 2, Large-scaled variety of Carp; 3, Crucian Carp; 4, Barbel ([illegible] nat. size).

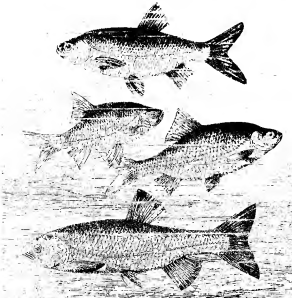
quently into Britain—it is said early in the seventeenth century. The ordinary form is shown in the upper figure of the illustration on p. 457; but there are many domesticated varieties, differing either in the form of the body or the size and arrangement of the scales. Among the latter, one of the most remarkable is the so-called *spiegel-karpfen* (mirror-carp), shown in the right-hand middle figure of the illustration. In this variety, which is found only in ponds, the scales are three or four times the normal size, and instead of covering the whole body are arranged in from one to three longitudinal rows, with bare skin between them. In Western Europe the carp has taken kindly to its new habitat, not unfrequently attaining as much as a yard in length with a weight of 25 lbs., while very much larger specimens are on record. Preferring still waters, with a soft muddy bottom in which it grovels with its snout for food, the carp feeds on various vegetable substances, as well as on insects and other small aquatic invertebrates. When the surface of their haunts is locked in ice, carp lie deeply buried in holes in the mud, frequently consorting in numbers, and undergoing a partial hibernation, which is not broken till the returning warmth of spring. Their growth is extremely rapid, and their fecundity extraordinary, nearly three quarters of a million eggs having been counted in the roe of a medium sized specimen. They are capable of living a considerable time out of water, especially if they are moistened from time to time; and are known to live to a very great age. Carp will interbreed both with the Crucian and golden carp.

Crucian and Golden Carp. Easily distinguished by the absence of barbels, the Crucian carp (*Carassius vulgaris*), and the golden carp, or gold-fish (*C. auratus*) are the best known representatives of another closely allied genus; the former being a native of Central and Northern Europe, but also found in Italy and Siberia, while the home of the second is China and the warmer parts of Japan. Both are comparatively small species, and have been long domesticated; whereas, however, the Crucian carp always retain the original brownish colour, the domesticated variety of the golden carp has assumed the well-known golden tinge from which it takes its name; an albino form being also known. Among the numerous varieties of this fish the most curious is the so-called telescope-fish, shown in the right-hand figure of the illustration on p. 412, taking its name from the prominence of the highly movable eyes, and likewise characterised by the great development of the caudal fin. In Europe gold-fish thrive best in waters heated somewhat above the ordinary temperature, and they are accordingly frequently kept in engine ponds, where the water may have a temperature of some 80°, and in which they breed freely. The Crucian carp, shown on the left of the illustration on p. 457, is confined to ponds and lakes, where it seeks the deepest parts.

Barbels. Represented by some two hundred species from the tropical and temperate regions of the Old World, the barbels are best known by the common European species (*Barbus vulgaris*), shown in the lower figure of the illustration on p. 457, and the gigantic mahasir (*B. tor*) of India and Ceylon. Agreeing with the carps in the structure of the anal fin, and the position of the lateral line and dorsal fin, they belong to a subgroup of genera in which there are generally not more than nine rays in the dorsal fin, the pharyngeal teeth being arranged in three rows, the greater part of the cheek not covered with bone, the anal scales not enlarged, and the eye unprovided with a fatty lid; while they are specially characterised by the arched mouth—which is devoid of internal folds—and by the presence of false gills. The anal fin is frequently tall, the lips are devoid of any horny covering, and the barbels, if present, may be either two or four in number. The scales may be either small or very large, and the body is frequently of a much more elongated form than in the true carps. While some species are not more than 2 inches in length, the mahasir, and some other kinds, may grow to at least 6 feet. Of the Indian forms, Day writes that those with four barbels (among which is the mahasir), "provided they are soberly coloured, attain a large size; the brilliantly coloured forms are mostly residents in clear or rapid mountain-streams, or rivers contiguous to hills, and generally small. A strong dorsal spine is usually (if not invariably) a sign that the species lives in the vicinity of high mountains, the streams of which it ascends to breed. An exception has, however, to be made of those forms with serrated dorsal spines, which are usually resident in the waters of the plains." The common barbel, which has four of the appendages from which it derives its name, not uncommonly grows to a length of 2 feet, with a weight of from 8 to 10 lbs., but may attain much larger dimensions.

Gudgeon Confining our attention mainly to the European representatives of the family, we have next to mention the gudgeons (*Gobio*), which may be distinguished from the foregoing by the pharyngeal teeth being arranged in a double or single series; the body being entirely covered with scales; and the muzzle having two small barbels, with the mouth inferior in position, and the premaxillary bones protractile. The scales are of moderate size, the short dorsal fin has no spine, and the intestine is remarkable for its shortness. These small fishes are represented only by two species, of which *G. fluviatilis* is British; and, like the barbels, they are purely animal-feeding. The British species is shown in the lower figure of the illustration on p. 462.

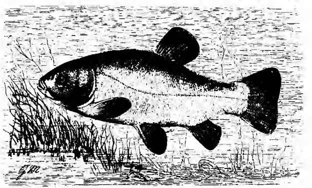
White-Fish. From the whole of the members of the family noticed above the so-called "white-fish" belong to a group of genera in which the anal fin is short or of medium length, with from eight to eleven branched rays, and not extending forwards beneath the line of the dorsal; the lateral line, when complete, running nearly or quite in the middle of the tail. From certain allied forms they are distinguished by the short dorsal fin having no bony ray; and the pharyngeal teeth form a single or double series, the margin of the lower jaw is not cutting, and there are no barbels. As distinctive peculiarities of the white-fish may be mentioned the protractile premaxillary bones, the imbricating scales, and the smooth outer surface of the pharyngeal teeth. The numerous representatives of the white-fish are distributed over the rivers of the North temperate zone, the New World forms somewhat exceeding in numbers those of the Old. Among the European representatives of the genus, the roach (*Leuciscus rutilus*) shown in the right-hand middle figure of our illustration, agrees with several other species in having a single series of pharyngeal teeth, at least ten rays in the anal fin, and the dorsal nearly opposite the pelvic fins; its deep body being silvery, and the lower fins of the adult generally tinged with red. Its range is confined to Europe north of the Alps. On the other hand, the chub (*L. cephalus*), shown in the lower figure of the illustration, may be selected as an example of a second group in which there are two series of pharyngeal teeth. This fish has a somewhat wider distribution than the last, extending southwards into Italy and eastwards into Asia; it is uniformly coloured, with greyish margins to the scales. To the same group of the genus belongs the dace (*L. vulgaris*), with the same distribution as the roach, to which it presents a considerable external resemblance, although smaller and longer in form;



GROUP OF WHITE FISH.
Ide, Rudd, Roach, and Chub (⅙ nat. size).

its sides being silvery, but the fins not tinged with red. Roach and dace are commonly found in company, and have identical habits. The fish shown in the upper figure of our illustration is confined to the central and northern countries of the Continent, where it is known as the ide (*L. idus*), and is a uniformly-coloured species nearly allied to the last. It is of special interest on account of a golden-coloured domesticated variety bred in Germany, and known as the orfe. Another member of the same group is the rudd or red-eye (*L. erythrophthalmus*), of which a specimen is represented in the left-hand middle figure of the illustration; this species, which ranges all over Europe and Asia, may be distinguished by its scarlet lower fins, the general hue of the scales being coppery. The familiar and diminutive minnow (*L. phoxinus*) differs from all the foregoing members of this group by the incomplete lateral line; its range being limited to Europe, although it is represented by an allied species in North America. The habits of all these familiar fish are too well known to need notice; but it may be mentioned that several of them will interbreed, as they will with species belonging to other genera of the family.

Tench. Representing a genus by itself, the European tench (*Tinca vulgaris*) differs from the white-fish by the presence of a small pair of barbels to the mouth; the pharyngeal teeth forming a single series. The small scales are deeply embedded in the thick skin; there is a complete lateral line; both the dorsal and anal fins are short; and the caudal, instead of having the markedly forked form characteristic of the roach and its allies, is but slightly emarginate. The terminally-situated mouth has its lips moderately developed. Whereas white-fish prefer clear running streams, the tench frequents ponds, lakes, and other more or less stagnant water; its colour, which is sometimes bronzy golden, and in other cases olive-green, with a more or less blackish tinge, is stated to vary with the purity or otherwise of the water in which it lives. Tench always keep near or in the mud, beneath which they entirely bury themselves during the colder months, after the fashion of so many members of the family. A good tench will weigh 4 lbs., but examples of 5 lbs., and even over, are not very uncommon. It is probably owing to the abundant supply of mucus secreted by the skin that the tench was considered to be endowed with healing powers. Tench are exceedingly prolific, and as they bear transport easily, are admirably adapted for stocking ponds.



TENCH (¼ nat. size).

Beaked Carp

By this name may be distinguished a small genus, **containing** seven species from Continental Europe and Western **Asia, and** differing from the two foregoing by the margin of the lower jaw forming **a cutting** edge overlain with a brown horny layer; one of the species (*Chondrostoma nasus*) being represented in the lower figure of the illustration on p. 465. **These fishes** are further characterised by the medium or small size of the scales, the **termination** of the lateral line in the middle of the deepest part of the tail, by the **dorsal fin** having not more than nine branched rays, and being situated opposite the **root** of the pelvics, and also by the rather elongate anal bearing ten or more rays. The mouth is inferior in position and transverse, and there are no barbels. Commonly known in France as *le nez*, the figured species does not usually exceed 18 inches in length, with a weight of about 3 lbs. It is generally found in deep water, where it feeds on various vegetable substances, but more especially on the green confervoid growth covering submerged stones, which is neatly mown off by a scythe-like action of the horny margin of the transverse lower lip.

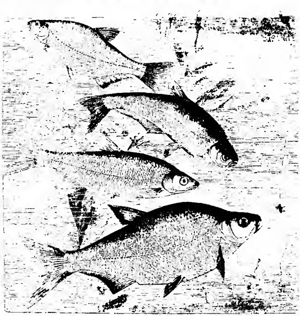
BITTERLING, BLEAK, AND CHUB (½ nat. size).

Bitterling

The small roach-like fish known as the bitterling (*Rhodeus amarus*), of which two examples are shown on the left side of the accompanying illustration, is the European representative of four genera of small carps mainly characteristic of Eastern Asia and Japan, and having the following distinctive features. The anal fin is of moderate length, and extends forwards to below the line of the dorsal; the lateral line, when fully developed, runs on or near the middle of the tail; and there is but a single series of pharyngeal teeth. The bitterling, which belongs to a genus characterised by the incomplete lateral line, and the small size of the scales, is locally distributed in Central Europe, where it is not unfrequently found in hot springs. It is one of the smallest of European fishes, the females being generally about 1½ inches in length, while the males do not exceed twice this size. The name is derived from the bitter taste of the flesh; and it is only perch and eels that will take this fish when used as a bait. In common with its allies, the bitterling is remarkable for the circumstance that in the breeding-season the oviduct of the female is produced into an elongated tube, projecting a considerable distance beyond the surface of the body. This organ, which may be compared to the ovipositor of an insect, is introduced within the shells of fresh-water mussels, and the eggs are thus deposited in a situation where they will be protected from the attacks of enemies.

Bream

The common European bream (*Abramis brama*), shown in the lower figure of the illustration on the next page, is the type of a large group of genera, characterised by the elongation of the anal fin, and by a portion or the whole of the abdomen being compressed so as to form a sharp edge. In the type genus the much compressed body is deep or oblong in form, with the scales of moderate size, and the lateral line running below the middle of the tail; the short dorsal fin, which is not furnished with a spine, being situated opposite the interval between the pelvic and anal fins. In both jaws the lips are simple, the upper being protractile, and generally longer than the lower, although occasionally the reverse condition obtains. The pharyngeal teeth may be arranged in either a single or double series; and the scales do not extend across the sharp edge of the lower surface of the hinder part of the body. Distributed over Europe north of the Alps, portions of Western Asia, and North America, the breams are represented by about fifteen species, of which the common bream and the white bream (*A. blicca*) are found in Britain. The white bream, shown in the upper figure of our illustration, has the general colour of the sides bluish white, without any trace of the golden yellow lustre, from the presence of which the common species is often termed the carp-bream. They may also be distinguished by the iris of the eye, in the latter being yellow, and in the former silvery white, tinged with pink. Yarrell writes that "bream swim in shoals, feeding on worms and other soft-bodied animals, with some vegetable substances; and if the water they inhabit suits them, which is generally the case, as they are hardy in their nature, they grow rapidly and spawn in May. At this season one female is generally followed by three or four males, and they bear at this time a whitish tubercle on their scales, which causes them to feel rough to the hand." In some of the Irish lakes bream run to as much as 12 or 14 lbs. in weight; and as they are a greedy fish, great numbers can be taken by the aid of ground-baiting. Of the other two species here figured, the zope (*A. ballerus*), forming the second figure from the top, is an inhabitant of Germany, Holland, and Sweden; while the zarthe (*A. vimba*), is found in the Danube, as well as in the rivers of North Germany, Sweden, and Russia. The latter species may be easily recognised by the keeled upper surface of the tail, and the projecting muzzle; while the zope is characterised by the great elongation of the anal fin, which commences opposite to the dorsal, and extends nearly to the tail, combined with the oblique direction of the cleft of the mouth.

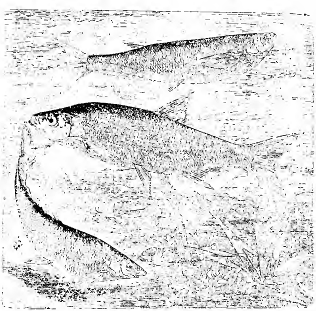


GROUP OF BREAM

White Bream, Zope, Zarthe, and Common Bream (¼ nat. size)

Rapfen By this name is known in Austria the typical representative (*Aspius rapax*) of a small genus of carps, containing four species from Eastern Europe and China, and somewhat intermediate in structural characters between the breams and the bleaks. Agreeing with the former in the shortness of the gill-rakers, these fishes always have the lower jaw projecting considerably beyond the upper, which is but slightly protractile; the anal fin never has less than thirteen rays; and the sharp lower edge of the abdomen behind the pelvic fins is crossed by the scales. Common in Eastern and Northern

Europe, although unknown in the British Islands, the rapfen, is generally found in lakes or rivers flowing through level country, as it requires clear but tranquil waters. In colour it is bluish black above, with the sides bluish white, and the under surface white; the dorsal and anal fins being blue, and the others tinged with red. In weight this fish does not exceed a dozen pounds, and in length never measures more than a yard.



SICHEL, RAPFEN, AND BEAKED CARP.

Bleak. Especial interest attaches to the beautiful little fish known as the bleak (*Alburnus lucidus*), of which a figure is given on the right side of the illustration on p. 462, on account of the use of the pearly matter from its scales in the manufacture of artificial pearls. Of bleak there are fifteen species, ranging over Europe and Western Asia; the common British species being found only to the north of the Alps, although represented by an allied form in Italy. From both the preceding genera these fish are distinguished by the slender and lanceolate form of the closely set gill-rakers. The body is more or less elongate, with the scales of moderate size, and the lateral line running below the middle of the tail. The fins are generally similar to those of the last genus; and the lower jaw projects more or less beyond the upper, which is protractile. In the hinder part of the abdomen the scales do not extend across the sharp lower edge. Generally about 4 or 5 inches in length, and never exceeding 7, the common bleak is steel-blue in colour above, with silvery white sides and under surface, and the dorsal and caudal fins grey, the others being colourless. It is found in rivers, lakes, and ponds, preferring clear water; and in calm, warm weather swimming rapidly about near the surface in search of flies and other insects. During the spawning-season, which is in May and June, bleak collect in large shoals, which are preyed upon not only by perch but likewise by gulls and terns.

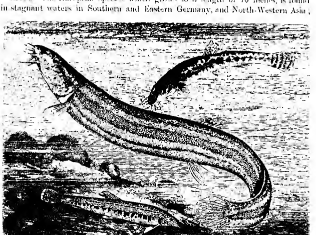
Nearly allied to the bleak is a small fish (*Leucaspius delineatus*) from the rivers of Eastern and Southern Europe, distinguished by the extreme shortness of the lateral line, which scarcely extends beyond the extremities of the pectoral fins. The scales also are of a regular ovate form, without the distinct fan-like rays so characteristic of the bleak.

Sichel

The last member of this great subfamily that we shall mention is the curious-looking fish (*Pelecus cultratus*) shown in the upper figure of the illustration on p. 465, known in Germany as the sichel, and forming the sole representative of its genus. It is at once characterised by the whole of the abdominal surface of the oblong and compressed body forming a sharp cutting edge; the scales being small, and the lateral line making a sudden descent behind the pectoral fin towards the lower surface. The cleft of the mouth is always peculiar in having a nearly perpendicular direction. The pectoral fins are unusually tall, and the dorsal is placed far back, and above the anal, which resembles that of the bream in its numerous rays. On the pharyngeal bones the teeth are arranged in a double series, and are strongly hooked. In profile this fish, which generally ranges from 6 inches to a foot in length, is remarkable for the straightness of the line of the back, and the convexity of its lower border. It is widely distributed in Eastern Europe, being common in the Black and Caspian seas, as well as in their affluent rivers. In form this fish makes a curious approach to the members of the herring tribe.

Loaches.

With the small fishes known as loaches, of which there are three European genera, we come to the second subfamily (*Cobitinæ*) of the carp tribe, which is characterised by the air-bladder being either partially or entirely enclosed in a bony capsule; false gills being always absent. In these fishes the body may be elongate, oblong, compressed, or cylindrical, but is never depressed; the muzzle and lips are fleshy; and the small, inferiorly-placed mouth is furnished with from six to twelve barbels. The median fins are spineless, the dorsal having a variable number of rays, but the short anal possessing but few, while the pelvic pair may be wanting; scales small, rudimental, or absent, and when present, cycloid, and usually immersed in mucus; in one Oriental genus, developed upon the back and sides of the head. The loaches of this subfamily are confined to Europe and Asia; and while some of those from the former continent are partial to swift clear streams with a stony bottom, the Indian forms delight in muddy tanks, where they bury themselves in the mud. All are carnivorous, and, in spite of their small size, the European species are esteemed as food. The giant loach (*Misgurnus fossilis*), forming the central figure of our illustration, is the largest European member of the group and belongs to a genus of four species, common to Europe and Asia north of the Himalaya. The genus is characterised by the elongate and compressed form of the body, the absence of an erectile spine near the eye and the presence of from ten to twelve barbels, four of which belong to the lower jaw, the dorsal fin being placed above the pelvic pair, and the caudal rounded. The European species which grows to a length of 10 inches, is found in stagnant waters in Southern and Eastern Germany, and North-Western Asia,



GIANT LOACH, COMMON LOACH, AND SPINY LOACH (½ nat. size).

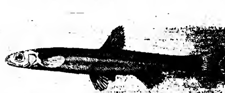
being replaced by an allied form in China and Japan. The true loaches (*Nemachilus*), on the other hand, have six upper barbels, and none on the lower jaw. They are represented by some fifty species from Europe and Temperate Asia; the common British loach (*N. barbatulus*), shown in the upper figure of the illustration, being found in clear streams all over Europe with the exception of Denmark and Scandinavia. The spiny loach (*Cobitis taenia*), shown in the lower corner of the illustration, is the typical representative of a third genus, distinguished from the last by the presence of a small bifid erectile spine below each eye. The figured species is locally and sparingly distributed in Britain, but more common on the Continent. Certain Indian loaches formerly included in this genus are now regarded as distinct, the subfamily being represented by eight other genera in the same country.

AFRICAN LOACHES.—Family *KNERIIDÆ*.

Two small loach-like fishes from the fresh waters of Tropical Africa, one of which (*Kneria angolensis*) is figured in the annexed illustration, alone represent a family distinguished from the preceding by the absence of teeth on the pharyngeal bones, and by the elongated air-bladder being undivided, barbels being wanting. While the figured species is from the west coast, the other (*K. spekei*) inhabits Central Africa.

THE CHARACINOID FISHES,—Family *ERYTHRINIDÆ*.

As an example of a very extensive family of fresh-water fishes, confined to Tropical America and Africa south of the Sahara, we select an American form known as the piraya (*Serrasalmo piraya*), since in our limited space it is quite impossible to deal with any of the others. It may be mentioned, in the first place,

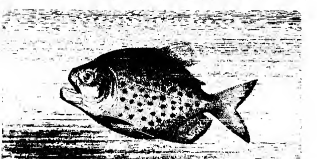


ANGOLA LOACH (nat. size).

that these fishes are commonly known as the *Characinidæ*, but as there is no such genus as *Characinus*, it is obvious that this term cannot stand, and we have accordingly adopted another. According to Professor Cope's arrangement, these fishes belong to the same sectional group as the carp tribe, from which they may be distinguished by the brain-case not being produced between the orbits, and likewise by the number of upper pharyngeal bones varying from four to one instead of being always two; a further point of difference occurring in the structure of the upper jaw, which is formed in front by the premaxillæ, and at the sides by the maxillæ. Like the carps, the body is scaled and the head naked; but barbels are invariably wanting, and the jaws may be either toothless, or furnished with a dentition of a very powerful type. In most cases there is a small fatty fin behind the dorsal; the air-bladder is always transversely divided into halves, and there are no false gills. Unfortunately, there are no fossil forms to aid in the explanation of the peculiar geographical distribution of the family, which is very similar to that of the chromids; but there can be little doubt that the ancestral types originally inhabited the great land-mass of the Northern Hemisphere, from whence they migrated southwards to their present isolated distributional areas. It is, however, not a little remarkable that whereas in their migration to Africa they have been accompanied by members of the carp tribe, in Tropical America they entirely take the place of that family. The numerous genera, none of which are common to the two hemispheres, are ranged under eleven groups or subfamilies, the majority of which are confined to either the one or the other half of the distributional area, although a few have representatives of both. As regards their habits, some of these fishes are strictly carnivorous, while others are as exclusively vegetable feeders.

The figured species belongs to the last subfamily, which includes four exclusively American genera, represented by some forty species, and characterised by the somewhat elongated dorsal fin, behind which is a small fatty fin; by the gill-membranes being free from the isthmus, and also by the distinct serration of the middle line of the under surface of the body.

On account of their large size, two other genera of these fishes, which have respectively received the names of *Hydrocyon* and *Cynodon*, must be mentioned; the former being from Tropical Africa and the latter from Brazil and the Guianas. They grow to the length of 4 feet, and are highly predacious; the subfamily to which they belong being characterised by the presence of a short dorsal and anal fin, the large conical teeth, the want of attachment between the gill-membranes and the isthmus, and the approximation of the nostrils.



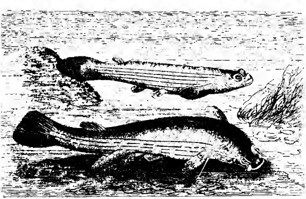
THE PIRAYA (½ nat. size).

THE CYPRINODONTS.—Family *CYPRINODONTIDÆ*

The small fishes which, for want of an English title, we may designate cyprinodonts bring us to the first family of another sectional group termed the Haplomi, which also includes the pikes. In addition to certain other structural features of the skeleton, this group is characterised by the first four vertebræ being separate and of normal form; while in the skull the parietal bones are separated by the supraoccipital, all the opercular bones are present, and the pharyngeals are distinct, the upper ones being directed forwards, and three or four in number. As a family, the cyprinodonts are specially distinguished by the margin of the upper jaw being constituted solely by the premaxillæ, and the enlargement of the third upper pharyngeal bone. Externally they may be readily distinguished from the carps by the head being scaled as well as the body, and they have no barbels. Both jaws are toothed, and the pharyngeals are also furnished with teeth, which are heart-shaped. There is no fatty fin, and the dorsal is situated in the hinder half of the body. The air-bladder is simple and the false gills are wanting. Inhabiting either fresh, brackish, or salt water, these fish are distributed over the south of Europe, Africa, Asia, and America; some being purely carnivorous, while others feed on the organic substances to be found in mud. Most of the forms are viviparous; and the males, which are much inferior in size to the females, and, according to Dr. Günther probably the smallest living fishes, frequently have the anal fin specially modified to aid in the reproductive process. As a rule, the fins are relatively larger in the males than in the females, and there is likewise some difference in the coloration of the two sexes. In a fossil state, remains of the typical genus occur in the Miocene strata of the Continent, which have also yielded others referred to an existing American genus; while the head of a species much larger than any now living has been described from the Pliocene of India, this specimen being figured in the accompanying illustration in order to show the scales on the head so characteristic of the family. Cyprinodonts are represented by about a score of genera, which may be divided into two subfamilies, according to the nature of the food. In the first of these, which includes the typical genus *Cyprinodon*, and has a distribution coextensive with that of the family, all the forms are carnivorous or insectivorous, and are characterised by the firm union of the two branches of the lower jaw in front, and likewise by the shortness, or slight convolution of the intestines. On the other hand, in the second subfamily, which is exclusively restricted to Tropical America, the species seek their food in mud, and have the two branches of the lower jaw but loosely joined together while the intestine is highly convoluted. It is in this group that the sexual differences are most strongly marked.

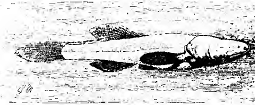
HEAD OF A FOSSIL CYPRINODONT, WITH ONE OF THE SCALES ENLARGED.

Double Eyes. As an example of the family we take a remarkable genus belonging to the first subfamily, represented by three species from Tropical America, one of which (*Anableps tetropthalmus*) is shown in the accompanying illustration. Having a broad and depressed head, with the region over the eyes much raised, the elongate body compressed in front and depressed behind, a protractile muzzle, and the cleft of the mouth horizontal and of moderate size, these fish are specially characterised by the structure of the eye, which is quite unique among vertebrates, and from which they derive their name. In each eye the integuments are divided into an upper and a lower moiety by a dark-coloured transverse band in the outer layer; the pupil being likewise bisected in the same plane by means of a lobe projecting from each side of the iris. The scales are of small or moderate size; the dorsal and anal fins short, the latter being placed in advance of the line of the former, and in the male (which in this genus is larger than the female) modified into a long, thick, sealy organ, with an aperture at the end. These fishes are the largest existing members of the whole family, growing nearly to a foot in length. They are abundant in North Brazil and the Guianas, where they frequent mud-banks on the coast and in the estuaries of the larger rivers, many of them being often left stranded by the retiring tide, where they progress on the slime by a series of leaps. After birth the young are carried about by the female in a thin-skinned sac divided by a partition until they are sufficiently advanced to take care of themselves. When swimming, these fishes frequently go on the surface with the eye half in and half out of the water, and it is in accordance with this habit that the eyes are divided, the upper portion being able to see in the air, while the lower is adapted for vision under water. That such is really the case, is proved by the structure of the lens of the eye. In terrestrial animals the lens is lenticular, that is to say, of the shape of two watch-glasses put edge to edge; whereas in ordinary fishes, which have to see in such a dense medium as water, the lens is spherical. Now in the double-eye that portion of the organ of vision which is above the level of the water has the lens lenticular, while in that portion which is below the water the lens is spherical. In Brazil the flesh of these fish forms an article of consumption.


FEMALE AND MALE DOUBLE-EYE (½ NAT. SIZE).

THE BLIND-FISH.—Family *AMBLYOPSIDÆ.*

The celebrated blind-fish (*Amblyopsis spelæus*) from the Mammoth Cave in Kentucky, the Wyandotte Cave in Indiana, and the subterranean streams which appear to connect the waters of the two, is generally regarded as the typical representative of a family closely allied to the last. This fish, which does not exceed 5 inches in length, and breeds viviparously, closely resembles the genus *Cyprinodon* in that certain specimens (which have unnecessarily been separated as *Typhlichthys*) lack the pelvic pair of fins. All traces of external eyes are wanting, and the skin is totally devoid of colour. In order to enable the creature to find its way about in the dark subterranean waters of the limestone rocks of the Central United States, its head is provided with a large supply of organs of touch, arranged in a series of transverse ridges on each side; while its sense of hearing is also stated to be very highly developed. Professor Cope writes that if these fish "be not alarmed, they come to the surface to feed, and swim in full sight like white aquatic ghosts. They are then easily taken by the hand or net, if perfect silence is preserved, for they are unconscious of the presence of an enemy except through the medium of hearing. This sense is, however, evidently very acute, for at any noise they turn suddenly downwards and hide beneath stones, etc., on the bottom. They must take much of their food near the surface, as the life of the depths is apparently very sparse. This habit is rendered easy by the structure of the fish, for the mouth is directed partly upwards, and the head is very flat above, thus allowing the mouth to be at the surface. It thus takes food with less difficulty than other surface-feeders, as the perch, where the mouth is terminal or even inferior; for these require a definite effort to elevate the mouth to the object floating on the surface." Nearly allied to that variety of the blind-fish in which pelvic fins are absent is a small fish known as *Chologaster*, in which small external eyes are retained, and the body is coloured, the front of the head being provided with a pair of horn-like appendages. These small fish were first known from three examples taken in the ditches of the South Carolina rice-fields, but a fourth specimen was captured in a well in Tennessee in the year 1854. The retention of the eyes and their dark colour indicates that these fishes have taken to a partially subterranean life more recently than the blind-fish.



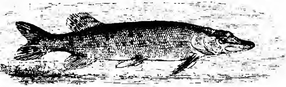
KENTUCKY BLIND-FISH (NAT. SIZE).

THE UMBRES.—Family *UMBRIDÆ*

A small fish from Austria-Hungary known as the umbre (*Umbra krameri*), together with a second (*U. limi*), locally distributed in the fresh waters of the United States, indicate a family distinguished from the *Cyprinodontidæ* by the upper jaw-margin being formed in front by the premaxillary bones and by the maxillary bones at the sides; the base of the skull being of simple structure in both families. Like the cyprinodonts, the umbres have the head and body scaled, and no barbels to the mouth. There is no fatty fin, and the dorsal is opposite the pelvics, or a little behind them, while the anal is short, and the caudal rounded. The stomach merely forms an expansion of the intestine; the air-bladder is simple; and the false gills are hidden and glandular. The European species, which is known as the *hundsfisch* in Germany, dwells in marshes and muddy pools, where it buries itself in the mud at the bottom. As in most cyprinodonts, the males are smaller and more slender than the females, scarcely reaching a couple of inches in length, whereas the latter grow to 3 or 3½ inches.

THE PIKE.—Family *ESOCIDÆ*

Such a familiar fish as the pike (*Esox lucius*) scarcely requires much in the way of description, but it is an important one as representing, with other members of the same genus, a family by itself. Agreeing with the umbres in the structure of the jaws, pike may be distinguished externally by the absence of scales on the head, and internally by the more complex structure of the base of the skull. The body is covered with cycloid scales; there are neither barbels nor a fatty fin; and the dorsal is situated in the caudal region of the vertebral column, in the position of the fatty fin of the salmon tribe. The stomach has no blind appendage, the false gills are glandular and concealed, and the gill-opening is unusually wide. In the upper jaw sickle-shaped teeth are borne by the premaxillæ, palatines, and vomer, the maxillæ being toothless, while the lower teeth are of variable shape. The long narrow body terminates in a forked caudal fin; and the long, broad, and depressed snout has the lower jaw exceeding the upper in length. Confined to the fresh waters of the temperate regions of the three northern continents, pike may be considered a western rather than an eastern type, seeing that whereas the common species has a range equivalent to that of the family, the whole of the other six species are confined to the United States. In Europe the pike inhabits

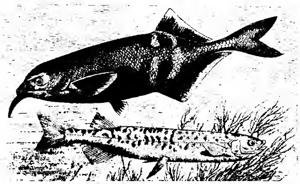


COMMON PIKE.

all the Russian rivers, with the exception of those of the Crimea and Transcaucasia, and is likewise found in Siberia. In Lapland it extends even beyond the limits of the birch, while to the south it is common in the Venetian lagoons. Growing very rapidly, the pike not uncommonly attains a length of 45 or 46 inches, with a weight of 35 or 36 lbs.; and although fishes of much larger dimensions are on record, the accounts of these must be received with great caution. It is pretty well ascertained that fish of 45 inches are not commonly more than about fifteen years old, and the stories of examples living for a century, or even more, appear to be legendary. Pike are among the most predaceous and greedy of all fresh-water fish, nothing coming amiss to their voracious appetites, since not only will they devour worms, leeches, frogs, trout, carp, and other fishes, but they pull under the young and often even the adults of all kinds of water-birds, and have no objection to an occasional water-vole. Their habit of lying like a log in the water (from which trait they probably derive their name), as well as the sudden rush they make after their prey, are well known to all; and the damage these fish do to trout-streams is almost incredible. Pike are also great devourers of the smaller members of their own kind. Frequenting alike ponds, lakes, and rivers, pike in Ireland spawn as early as February, but in England a month or two later, while in some parts of the Continent the season lasts till May. Males, which are inferior in size to their consorts, are said to be more numerous than the latter; and it is not uncommon for a female in spawning-time to be attended by three or four members of the opposite sex, who crowd around her as she lies quiet to deposit her eggs.

THE AFRICAN BEAKED FISH,—Family *MORMYRIDÆ*.

The very remarkable fish (*Mormyrus petersi*) shown in the upper figure of the illustration on p. 475 is the best known African representative of a large genus of fresh-water fishes confined to Africa, and constituting not only a family but likewise a distinct section, to which Professor Cope applies the name of Scyphophori. Having the narrow parietal bones of the skull distinct both from one another and from the supraoccipital, these fishes are especially distinguished by having each of the pterotics (which lie on each side of the parietals) large, funnel-shaped, and enclosing a cavity expanding externally and covered by a lid-like plate of bone. The anterior vertebræ are simple and unmodified; and a subopercular bone is present in the gill-cover. Externally both the body and tail are covered with scales, but the head is naked, and the muzzle has no barbels. In the upper jaw the middle portion is formed by the united premaxillæ, and the sides by the maxillæ; the gill-opening is reduced to a small slit; there are no false gills; and the air-bladder is single. A fatty fin is wanting; and whereas in the typical genus all the other fins are well developed, in the allied *Gymnarchus* (which is likewise exclusively African, and is sometimes regarded as the representative of a distinct family) the caudal, anal, and pelvic fins are wanting, the tail tapering to a point, instead of terminating in a deeply forked fin. The beaked fishes are divided into groups according to the length of the dorsal fin and the form of the muzzle, the figured species belonging to a group in which the dorsal fin is relatively short, scarcely exceeding the anal in length, while the muzzle is long and bent down. From its nearest allies the species in question is distinguished by the production of the extremity of the lower jaw into an elongated, conical, dependent, fleshy appendage, nearly equal in length to half the head. In colour the skin is dark brown, relieved by two lighter crossbands between the dorsal and anal fins. Other species have the muzzle short and blunt; and whereas some grow to a length of between 3 and 4 feet, others are comparatively small fishes. No less than eleven species of this genus are found in the Nile; which, together with some of the West African rivers, is likewise the home of the single representative of the genus *Gymnarchus*. In form the latter fish is eel-like; its jaws being armed with a series of incisor-like teeth, and its length reaching to upwards of 6 feet. Both genera are furnished with a pair of organs lying on the two sides of the tail, which are stated to be transitional in character between ordinary muscle and a true electric organ; although, if this be correct, it is difficult to conceive what can be the object or use of such a structure. Each consists of an oblong capsule, divided by vertical partitions into a number of chambers filled with a gelatinous substance. One of the species (*M. oxyrhynchus*) from the Nile, is frequently depicted in the frescoes of the ancient Egyptians.



PETERS' BEAKED FISH AND SLENDER [illegible] ([illegible] NAT. SIZE).

SECTION ISOSPONDYLI[1]

THE FEATHER-BACKS.—Family *NOTOPTERIDÆ*.

According to the classification we are following, the whole of the remaining members of the tube-bladdered fishes form a group denominated Isospondyli, and characterised as follows. The parietal bones are completely separate; the symplectic bone, which is wanting in the group last treated of, is present; the anterior vertebræ are simple and unmodified, and both the upper and lower pharyngeal bones are separate. The group includes the least specialised of all the bony fishes, and those forming a transition to the ganoids. From the peculiar form of the dorsal fin certain fresh- and brackish-water fishes from West Africa and the Oriental region, one of which (*Notopterus borneensis*) is shown in the illustration herewith, have received the not inappropriate name of feather-backs. They constitute a family differing from all the others in this section by the tail being tapering and fringed inferiorly by a continuation of the anal fin, as well as by the presence of a cavity in the ring-like pterotic bone, the base of the skull being double. Both the body and the head are covered with small scales; barbels are wanting; the margin of the upper jaw is formed in front by the premaxillæ and at the sides by the maxillæ: and the opercular bones are incomplete. There is no fatty fin, and the dorsal, when present, is very short, and situated in the caudal region; the pelvic pair being rudimental or wanting. The air-bladder is divided internally into several compartments and terminates at each end in a pair of narrow prolongations, of which the anterior ones are in communication with the organ of hearing. A further peculiarity is that the spawn falls into the cavity of the abdomen previous to its exclusion. There are two Indian representatives of the genus, one of which grows to a couple of feet in length: a third is Bornean, and the other two are West African. An extinct species has been described from the Eocene of Sumatra.

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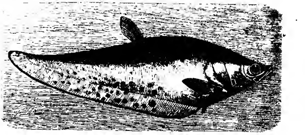
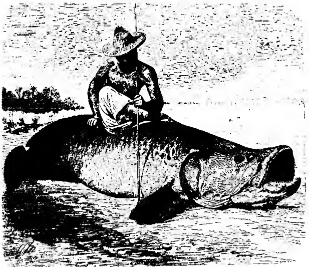
[1] On p. 333 the group Isospondyli is given as of equivalent rank with the Physostomi, of which, in the scheme here followed, it should be only a section.



BORNEAN FEATHER-BACK ($\frac{1}{3}$ nat. size).

THE SOUTHERN PIKELETS.—Family *GALAXIIDÆ*

For want of a better name we may designate by the name of southern pikelets a genus of small fresh-water fishes from the Southern Hemisphere, one of which (*Galaxias attenuatus*) is represented in the lower figure of the illustration on p. 475. Together with the members of the next family, these fishes are distinguished from the other genera of the present sectional group noticed here by having the base of the cranium simple, the tail being rounded or forked, and the pterotic bone devoid of a cavity in its interior. Externally these fishes may be recognised by the naked body and the absence of barbels; the fatty fin being absent, and the medium-sized dorsal opposite the anal. Internally the air-bladder is large and simple; and the eggs, as in the last family, fall into the abdominal cavity. Represented by rather more than a dozen species, the largest of which seldom exceeds 8 inches in length, these fish are of especial interest from a distributional point of view, since they occur in such isolated areas as New Zealand, New South Wales, Tasmania, and the southern extremity of South America. From their spotted bodies the New Zealand representatives of the genus were formerly known as trout by the colonists. An allied New Zealand genus (*Neochanna*), represented by a single species, differs in the absence of pelvic fins; all the known specimens of this singular form having been found buried in burrows of clay or hard mud at a considerable distance from the water.



BRAZILIAN ARAPAIMA ([illegible] NAT. SIZE).

THE ARAPAIMAS,—Family *OSTEOGLOSSIDÆ*.

Agreeing with the last family in the conformation of the base of the skull, **the large tropical** fresh-water fishes, which may be collectively known as arapaimas **(although this** name properly belongs only to the Brazilian species here figured), are fully as interesting as the latter from their geographical distribution, which presents a curious general similarity to that of the existing lung-fishes, although in the present instance one of the genera has a much wider range than either of the lung-fishes. In confirmation of the northern origin of the present group, it is noteworthy that an arapaima exists in Sumatra, and also that an extinct genus (*Dapedoglossus*) occurs in the Eocene strata of the United States. From the preceding the more typical representatives of this family are structurally distinguished by the upper pharyngeal bones being three, instead of only two in number. Externally these fishes have the body covered with large, hard scales of a mosaic-like structure; the lateral line being formed by wide openings of the mucus-canal; and the scaleless head nearly covered with roughened ossifications of the skin. The margin of the upper jaw is formed both by the premaxillæ and maxillæ, the gill-openings are wide, and false gills are wanting. The long dorsal closely resembles the anal fin, over which it is placed in the caudal region of the body; both coming very close to the tail-fin, with which they may unite as an abnormality. In structure the air-bladder may be either simple or divided into cells.

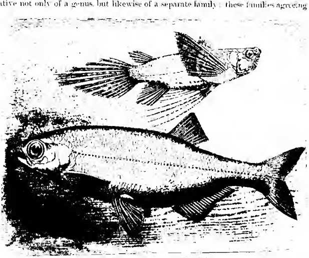
Arapaima. The true arapaima (*Arapaima gigas*) of the larger rivers of Brazil and the Guianas, which is the sole representative of its genus, occupies the proud position of being the largest fresh-water bony fish, its length not unfrequently exceeding 15 feet, while its weight may reach upwards of 400 lbs. As a genus, it is distinguished by the broad cleft of the mouth, in which the lower jaw is very prominent, and the absence of barbels, as well as by the rounded lower surface of the body, and the moderate length of the pectoral fins. In addition to an outer series of small conical teeth in the margins of the jaws, there are rows of rasp-like teeth not only on all the bones of the palate, but likewise on the tongue and hyoid bones. In spite of its enormous dimensions, the arapaima is captured by the natives of Brazil with a hook and line; its flesh being highly esteemed as food, and in a salted condition largely exported. It is also taken by being struck with an arrow, to which a line is attached, and a graphic account of this method of hunting is given by Schomburgk. It appears that a party go out in a boat and row about until a fish is sighted, when the bow and arrow are brought into requisition, and if the shot be successful, the monster is at length landed.

Barbelled Arapaimas. The four representatives of the typical genus *Osteoglossum* may be distinguished from the last by the presence of a pair of barbels to the lower jaw, the obliquity of the cleft of the mouth, the sharp lower surface of the body, and the greater length of the pectoral fins. Of the four species the first is American, and has the same distribution as the true arapaima, the second occurs in Sumatra and Borneo, while the other two are Australian. The two latter have, however, but a very local distribution, the one (*O. leichardti*) being confined to the rivers of Queensland, where it is known to the natives as the barramundi, and to the colonists as the Dawson River salmon; while the second (*O. jardinei*), which is distinguished by the absence of a spine to the anal fin, inhabits the rivers discharging into the Gulf of Carpentaria. The flesh of both these species is highly esteemed as an article of food.

Small Mouthed Arapaima. The third genus of the family, which includes only a single species (*Heterotis nilotica*), differs from both the foregoing in having the pharyngeal bones numerically the same as in the southern pikelets, on which account Professor Cope regards it as the type of a distinct family. Differing from the other two genera in the comparatively small size of the cleft of the mouth, and also in the approximate equality of the length of the jaws, this fish has no barbels, and only a single series of teeth in the jaws, teeth being also present on the pterygoid and hyoid bones, but wanting on the vomer and palatines. A further peculiarity is to be found in the presence of a peculiar spiral organ on the fourth gill-arch; and the air-bladder differs from that of the other members of the family in its cellular structure, while the stomach comprises a membranous and a muscular portion. The fish in question is found alike in the upper Nile and in the rivers of Western Africa. It grows to about 2 feet in length.

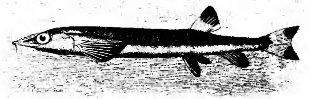
MOON-EYE AND CHISEL-JAW.—Families *HYODONTIDÆ* and *PANTODONTIDÆ*.

Each of the two fishes figured in the annexed illustration is the only representative not only of a genus, but likewise of a separate family; these families agreeing with all the remaining ones of the present section in having the pterotic bone normal, the base of the skull double, and four upper pharyngeal bones all of which are distinct, and the third the largest and directed forwards. In the first family the parietal bones are united, and there are two true tail-vertebræ in front of the complex bone supporting the rays of the caudal fin.


CHISEL-JAW AND MOON-EYE ([illegible] NAT. SIZE).

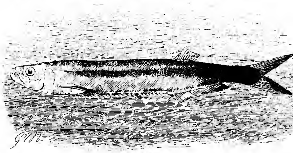
Moon Eye. Externally, the moon-eye (*Hyodon tergisus*), as the single representative of the first of the two families is popularly termed, has the body covered with cycloid scales, the head naked, and no barbels. The margin of the upper jaw is formed by the premaxillæ in front and the maxillæ at the sides, the latter bones being articulated to the former at the point of junction: and all the elements of the gill-cover are present. There is no fatty fin and the short dorsal is placed in the caudal region, above the fore-part of the longer anal: the caudal fin being forked. The gill-openings are wide; the stomach is horseshoe-shaped, the intestine short, and the air-bladder simple; false gills being absent. In form the body is oblong and compressed, with a part of the lower surface forming a sharp edge; and the cleft of the mouth is somewhat oblique; all the bones of the palate bearing small teeth, and the edges of the tongue carrying a larger series. Before their exclusion, the eggs fall into the cavity of the abdomen. The moon-eye shown in the lower figure of the cut on p. 479, grows to a length of from 1 foot to 18 inches, and is confined to the fresh waters of North America, where it is abundant in the lakes and rivers of the western side of the continent.

Chisel-Jaw. The small fish (*Pantodon buchholzi*) represented in the upper figure of the cut on p. 479 was discovered not very many years ago in the rivers on the West Coast of Africa, and takes its name from the strong dental armature of the jaws. Remarkably like a cyprinodont in external appearance, this fish has the body covered with relatively large scales, and the sides of the head with bony plates; the margin of the upper jaw being formed in front by the united premaxillæ, and at the sides by the maxillæ. The short dorsal fin is situated still further back than in the last genus, its front margin being considerably behind that of the rather longer anal; both the pectoral and pelvic fins are very tall, the rays of the latter forming isolated filaments, and the caudal is long and pointed, with some of its rays projecting. The muzzle is blunt, and the cleft of the mouth directed upwards. In the gill-cover there is only an opercular and a preopercular bone, the gill-openings are wide, and the branchiostegal rays are numerous. False gills are absent; the air-bladder is simple; and the ovaries of the female, and the corresponding organs of the opposite sex, are furnished with a duct.



BEAKED SALMON (⅓ nat. size).

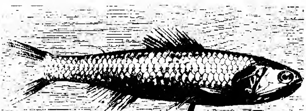
Monsieur Filhol writes that "the existence of eyes in fishes which we believe to live in a dark medium seems at first sight impossible to understand. But this fact receives an explanation when we learn that the creatures furnished with these organs are covered with a coating of luminous mucus, or bear phosphorescent plates. The phosphorescence with which the fishes of the ocean depths are endowed serves indeed both to guide them and to attract their prey, fulfilling for them in the latter case the same office as a torch in the hand of a fisherman. This peculiarity has been long noticed in surface-fishes which pursue their prey at night; Bennett, for instance, having described a shark which gives off a bright green phosphorescence from the lower surface of its body. On one occasion that zoologist brought into a room a freshly-caught specimen of this shark, upon which the whole chamber was illuminated with the light given off from its body. It is probable that the different species of sharks living at moderate depths, like the one described by Bennett, make use of their luminosity solely for the purpose of attracting their prey within reach. In most cases the origin of this light-giving mucus must be attributed to glandular organs distributed along the flanks and tail, on the head, and more rarely on the back. There exists, however, in certain fishes, which lack these glandular organs, an apparatus of a totally different nature for the emission of light; this apparatus consisting of a kind of biconvex transparent lens closing the front of a chamber filled with clear fluid. This cavity is carpeted by a blackish membrane formed of hexagonal cells, thus recalling the retina of the eye, and is connected with certain nerves. Phosphorescent plates of this type may be situated either beneath the eyes, or on the sides of the body," one of the fishes thus furnished belonging to the family now under consideration, in which it forms the genus *Malacosteus*. A specimen of this fish captured before death had ensued was observed to emit a yellowish light from the uppermost plate beneath the eye, while that from the lower plate had a greenish tinge. In the genus *Stomias*, continues our author, "the sides of the body present a double longitudinal series of phosphorescent plates, which emit light in such a manner as to cause the



THE DORAB (1/10 nat. size).

tropical seas; they are so numerous that the surface-net, when used during a night of moderate weather, scarcely ever fails to enclose some specimens. They come to the surface at night only; during the day, and in very rough weather, they descend to depths where they are safe from sunlight or the agitation of the water. Some species never rise to the surface; indeed, scopeli have been brought up in the dredge from almost any depth to two thousand five hundred fathoms." Upwards of thirty species of this genus are known, and there is also an allied genus (*Gymnoscopelus*) distinguished by the absence of scales.

Among several other remarkable forms of the family, we may especially notice a very curious fish (*Ipnops*) obtained at great depths during the voyage of the *Challenger*. Possessing an extremely elongate and cylindrical body, covered with large, thin, deciduous scales, this fish has a depressed head and an elongate, broad, spatulate muzzle, of which the whole upper surface is occupied by a luminous or visual organ divided longitudinally into two halves, and representing the highly-modified eyes. The whole length of this strange fish does not exceed between 5 and 6 inches. Another deep-sea fish (*Plagyodus*) is noteworthy on account of its large dimensions, and the formidable armature of its mouth; the scaleless body being long and compressed, the snout much produced, and the teeth of the jaws and palate of very unequal size, some forming long and sharply-pointed tusks.



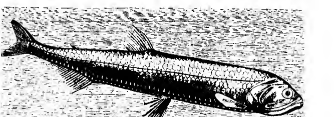
PHOSPHORESCENT SARDINE (nat. size).

THE PHOSPHORESCENT SCOPELOIDS,—Families *STERNOPTYCHIDÆ* and *STOMATIDÆ*.

More or less nearly allied to the scopeloids are two families of deep-sea or pelagic fishes usually bearing phosphorescent organs along the sides of the body; an example of each being represented in the accompanying illustration.

Silvery Light Fish. The fish (*Photichthys argenteus*) shown in the upper figure of the illustration, is taken as our representative of the first of the two families, of which, in addition to the phosphorescent organs, the leading characters are as follows. The body may be either covered with thin deciduous scales or entirely naked; barbels are wanting; and the fatty fin is either rudimental or of very minute size. Both the premaxillæ and maxillæ take a share in the formation of the margin of the upper jaw, and bear pointed teeth of variable length. The bones of the gill-cover are not fully developed; the gill opening is of great width; false gills may or may not be developed; and, when present, the air-bladder is of simple structure. The ovaries are furnished with ducts. Whereas in the figured species the teeth are small, in the allied genus *Chauliodus* they are greatly elongated, and thus indicate highly predaceous habits on the part of their owner.

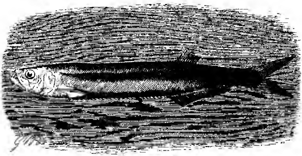
Hedgehog Mouths. The members of the second family, of which the bearded hedgehog-mouth (*Echiostoma barbatum*), shown in the lower figure of our illustration, is taken as an example, may be readily distinguished from the



SILVERY LIGHT-FISH, AND BARBED HEDGEHOG-MOUTH ([illegible] nat. size).

preceding by the presence of a long barbel to the hyoid; the skin being either naked or covered with exceedingly delicate scales, and the fatty fin (as in the figured specimen) frequently wanting. In other characters these fishes closely resemble those of the preceding family. When a fatty fin is present, as in the genus *Astronesthes*, the rayed dorsal is of considerable length, and placed in advance of the anal; but in the other genera both the anal and dorsal are short, and placed opposite to one another a short distance in advance of the forked caudal. In the genus represented by the figured species the body is naked and the pectoral fins are filamentous; but in the allied *Stomias* there are exceedingly small scales which scarcely overlap one another. Occasionally met with floating in a helpless condition, these fishes have been dredged from depths of eighteen hundred fathoms; and it will not escape the notice of the reader that, although dwelling in total darkness, they, like most of their allies, have well-developed eyes. On this point

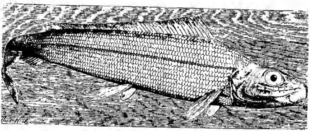
Monsieur Filhol writes that "the existence of eyes in fishes which we believe to live in a dark medium, seems at first sight impossible to understand. But this fact receives an explanation when we learn that the creatures furnished with these organs are covered with a coating of luminous mucus, or bear phosphorescent plates. The phosphorescence with which the fishes of the ocean depths are endowed serves indeed both to guide them and to attract their prey, filling for them in the latter case the same office as a torch in the hand of a fisherman. This peculiarity has been long noticed in surface-fishes which pursue their prey at night; Bennett, for instance, having described a shark which gives off a bright green phosphorescence from the lower surface of its body. On one occasion that zoologist brought into a room a freshly-caught specimen of this shark, upon which the whole chamber was illuminated with the light given off from its body. It is probable that the different species of sharks living at moderate depths, like the one described by Bennett, make use of their luminosity solely for the purpose of attracting their prey within reach. In most cases the origin of this light-giving mucus must be attributed to glandular organs distributed along the flanks and tail, on the head, and more rarely on the back. There exists, however, in certain fishes, which lack these glandular organs, an apparatus of a totally different nature for the emission of light: this apparatus consisting of a kind of biconvex transparent lens closing the front of a chamber filled with clear fluid. This cavity is carpeted by a blackish membrane, formed of hexagonal cells, thus recalling the retina of the eye, and is connected with certain nerves. Phosphorescent plates of this type may be situated either beneath the eyes, or on the sides of the body," one of the fishes thus furnished belonging to the family now under consideration, in which it forms the genus *Malacosteus*. A specimen of this fish captured before death had ensued was observed to emit a yellowish light from the uppermost plate beneath the eye, while that from the lower plate had a greenish tinge. In the genus *Stomias*, continues our author, "the sides of the body present a double longitudinal series of phosphorescent plates, which emit light in such a manner as to cause the


THE DORAB ($\frac{1}{5}$ nat. size).

whole fish to be bathed in a brilliant luminous halo. This fish must, indeed, be a formidable creature to the other inhabitants of the ocean abysses; being in every way constructed and armed for strife, and its powerful teeth admirably fitted to seize and tear the flesh of the other fishes upon which it preys." In other species (*e.g. Eustomias*) the barbel is greatly lengthened, all the fins form long dentated filaments; the whole of these structures being apparently modified for the emission of phosphorescent light. In our figured species not only are there luminous dots down the sides of the body, but also larger plates beneath the eyes.

THE DORAB,—Family *CHIROCENTRIDÆ*

With the fish represented in the accompanying illustration, which ranges from the Red Sea to the Malay Archipelago, and is commonly known in the East as the dorab (*Chirocentrus dorab*), we come to the first of what we may term the



LONG-FINNED HERRING (⅛ nat. size).

herring and salmon group, the more typical members of which differ from the preceding families of this section in having the parietal bones of the skull separated from one another by the intervention of the supraoccipital. In common with the herrings, this fish, which is the sole representative of its family, has but a single true tail-vertebra. Externally the body is covered with thin deciduous scales; barbels, and a fatty fin are alike lacking; but the elements of the gill-covers are fully developed. The margin of the upper jaw is formed partly by the premaxillæ and partly by the maxillæ, which are firmly welded at their junction; the short dorsal fin is situated in the caudal region of the vertebral column above the much longer anal, the tail is deeply forked, the pelvic fins are minute, the lower surface of the body is sharp, the gill-opening wide, and false gills wanting. The upward direction of the cleft of the mouth, which is armed with formidable teeth, coupled with the elongation of the lower jaw, gives a rather peculiar expression to the head, and the eyes are remarkable for being covered with skin. The stomach is furnished with a blind appendage, the intestine is short, and the air-bladder cellulated. As this fish attains a length of fully a dozen feet it is a sufficiently formidable monster, and when captured is said to bite viciously at every object within reach. Its flesh is of poor quality. It has been considered that the extinct *Chiromystus*, from the Eocene of Brazil, may belong to this family.

LONG-FINNED HERRING,—Family *BATHYTHRISSIDÆ*.

Although its osteology has not apparently been described, we may place here the fish (*Bathythrissa dorsalis*) shown in the illustration on p. 485, which is another of the numerous forms in the present section representing a family by itself. Having an oblong body, with a rounded under surface, invested with cycloid scales, the head naked and devoid of barbels, and no fatty fin, this fish may be at once recognised by the great length of the many-rayed dorsal fin, which occupies nearly the whole length of the back, and is situated in advance of the short anal. There is no air-bladder, and very small eggs are produced by the ductless ovaries. This fish, which attains a length of two feet, has been obtained in Japanese waters at a depth of between three and four hundred fathoms.

THE EXTINCT SAURODONTS, Families *ENCHODONTIDÆ*, *SAUROCEPHALIDÆ*, etc.

Before proceeding to the consideration of the herrings, we may briefly refer to a group of more or less closely allied extinct families, mainly characteristic of the Cretaceous period, but also represented in the lower Tertiaries. From the large size of their lanciform, reptile-like teeth, all the members of the group are collectively spoken of as the saurodont fishes.

SKELETON OF A SAURODONT FISH (*Eurypholis*).

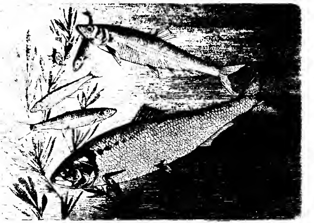
The first family (*Dercetidæ*) is typified by the genus *Dercetis*, of the Chalk, and is characterised by the elongated form of the body, the large size of the teeth, which are implanted in sockets, and the presence of several rows of large triangular bony plates along the sides of the body; the muzzle being frequently produced into a beak, and the dorsal fin single. Nearly allied is the family (*Enchodontidæ*) represented by the widely spread Cretaceous genera *Enchodus* and *Eurypholis*; these fishes having the body moderately compressed, and either naked or partially protected by bony plates, and the elongated upper jawbones armed (like those of the lower jaw) with small, immovably welded teeth. To a third family belongs the genus *Saurocephalus*, from the North American Cretaceous, which, together with the allied forms, has the body much compressed, the large upper jaw armed with powerful teeth, usually set in sockets, and a single series of similar teeth in the lower jaw, the palatine bones being toothless. A peculiarity of the vertebræ of these fishes, with the exception of those of the neck, is the presence of two deep grooves and pits on their sides. Some of these fish attained huge dimensions; the American and Australian Cretaceous genus *Portheus* being distinguished by the presence of an enormous bony crest in the middle line of the skull.

THE HERRING TRIBE.—Family *CLUPEIDÆ*.

Second to none in their commercial importance, the herring tribe are remarkable for the enormous number of individuals by which several of the species are represented rather than for the multiplicity of the species themselves; this being probably one of the chief reasons for the great value of these fishes as a food-supply. Although the existing representatives of the family may be readily distinguished from the salmonoids by the absence of a fatty fin, yet extinct forms indicate such an intimate connection between the two groups as to induce some naturalists to include both in a single family. Whatever may be the ultimate verdict on this point, in a work like the present, where we are mainly concerned with living types, it is obviously preferable to follow the ordinary system. While the typical representatives of the family have the parietal bones of the skull separated by the supraoccipital and but one true tail-vertebra, in the genus *Elops* the parietals are in contact and there are two caudal vertebræ. On this account it has been proposed to make the latter genus the type of a distinct family, a similar proposal having been made in the case of an analogous departure from the ordinary type among the salmonoids. In addition to the absence of the fatty fin, most herrings are characterised by the presence of small bony plates on the lower margin of the body. Externally the whole body is scaled, with the lateral line mostly wanting; while the head is generally naked, and the muzzle always without barbels. The under surface is more or less compressed, and generally so much so as to form a sharp edge, which is usually serrated. In the gill-cover the four elements are present, and the gill-openings are in most cases very wide. Both premaxillæ and maxillæ enter into the formation of the margin of the upper jaw, but each of the latter bones is peculiar in being composed of three separate pieces. The single short dorsal fin has a small or moderate number of weak rays, and the anal may be many-rayed. The stomach is furnished with a blind sac; the air-bladder is of more or less simple structure; and well-developed false gills are usually present. Distributed over all temperate and tropical seas, herrings are mainly littoral fishes, none of them being inhabitants of deep water, and none truly pelagic. Although the majority are marine, many of them will enter fresh water, and some live permanently therein, while it is probable that all can be acclimatised to such conditions. As might have been expected from their generalised structure, herrings are an ancient group, the typical genus dating from the period of the Chalk, while anchovies and other existing generic types are known from the Eocene. A number of more less nearly allied Cretaceous genera appear to connect the family very closely with the higher ganoids.

Typical genus.

The common herring (*Clupea harengus*) belongs to a group of genera characterised by the equality in the length of the two jaws, the presence of free fatty lids to the eyes, and the serration of the lower border of the hinder part of the body; the typical herrings being distinguished from the allied genera by the anal fin being of moderate length, with less than thirty rays, and the serration of the under surface commencing from the chest or point of origin of the pectoral fins. Usually the scales are of moderate or large size, although they may be small; the cleft of the mouth is of medium width; and if teeth are present at all, they are rudimental and deciduous. In position the dorsal fin is opposite the anal and the caudal is deeply forked. Represented by some sixty species, the genus has a distribution coextensive with that of the family; but whereas the flesh of the majority of its representatives is of excellent quality, that of some tropical forms may acquire poisonous properties. In the case of such a well-known fish as the common herring it will be superfluous to give any description; but it may be mentioned that this species may be distinguished from its allies by the presence of a patch of small ovate teeth on the vomer. It has also the dorsal fin situated exactly midway between the extremity of the muzzle, and the longest ray of the caudal fin, and the pelvic fins are directly under the dorsal.



SHAD, SPRATS, AND HERRING (the shad $\frac{1}{5}$, the others $\frac{1}{3}$ nat. size).

Whitebait are for the most part the young of this species. Common to both sides of the cooler regions of the Northern Atlantic, the herring ranges eastwards to the seas on the north of Asia. Associating in shoals numbering millions of individuals the herring feeds upon crustaceans, worms, insects, and the young and eggs of other fishes, as well as those of its own kind. "During the day," writes Mr. J. M. Mitchell, "the shoals are sometimes observable near the surface, and may be seen playing on the water as the fishermen call it, making a ripple,—a dark roughness similar to what we may see at the beginning of a slight breeze, this being somewhat observable without the appearance of either whales or birds. The passing near or over them of a boat or ship makes them instantly dart off in every direction, having the appearance of long trails of light if at night. We have been informed by fishermen of Newhaven that the herrings take considerable flights out of the sea; off Stonehaven, in the month of September, one of these men having seen a shoal, after the spawning season, rise up out of the water in a vast mass of many yards in extent, sparkling and flashing, and flying several feet above the surface. . . . On some of the coasts, as on those of Norway, the herring-shoals are frequently accompanied or pursued by numbers of whales and aquatic birds, which are all occupied in preying on them. The large dark masses of the whales rising and blowing and throwing up great quantities of the herring into the air, sparkling and glittering in the clear winter day; the constant movements of the birds, with their shrill notes, actively engaged in seizing their easily-obtained food, vying with man in their attacks on the countless myriads of herrings, form a most wonderful sight. . . . When the herrings swim near the surface, if it is calm weather, the sound of their motion is distinctly heard at a small distance; and at night their motion, if rapid, causes a beautiful bright line from the phosphorescent quality of the skin; and it is also said, that when a great body of them swims near the surface, their presence is ascertained by a strong fishy smell." In another passage, after stating that the idea of fish migrating from the Arctic regions southwards is purely erroneous, the same author observes that "from all circumstances known of the natural history of the herring, in regard to its visits on our own coasts and the coasts of other countries, it is reasonable to suppose that it inhabits the seas in the neighbourhood of the coasts on which it spawns, and that it arrives at particular seasons near the coasts for the purpose of spawning, the shoals leaving the coasts immediately thereafter; and the early or late, distant or near, approach to the coast in different years, perhaps depends on the clear and warm or dark and cold weather of the seasons, as well as upon the depth of water at the feeding and spawning grounds." Herrings have been kept in a brackish-water pond communicating with the Humber, where they became dwarfed in size.

The much smaller sprat (*C. sprattus*), so abundant on the Atlantic coasts of Europe, differs by the absence of vomerine teeth; while the shad (*C. finta*), shown in the upper figure of the illustration on p. 488, may be distinguished by having one or more black blotches on the sides. In this species, which not only frequents the European coasts, but ascends rivers, and is abundant in the Nile, the bony gill-rakers, of which there are from twenty-one to twenty-seven on the horizontal portion of the outer gill-arch, are short and stout. On the other hand, in the similarly spotted allice-shad (*C. alosa*) the gill-rakers are very long and fine, and number from sixty to eighty on the part mentioned. Both the shads are considerably larger than the herring. Whereas in both the herring and the sprat the opercular bone is smooth, in the pilchard or sardine (*C. pilchardus*) this part is marked by ridges radiating towards the suboperculum. This species is abundant in the English Channel, the seas of Spain and Portugal, and the Mediterranean; Vigo Bay being noted for its sardine-fishery.

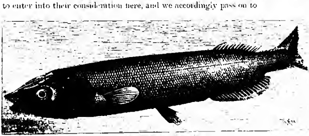
The following account of the sardine-fishery is taken from the *Asian* newspaper. "Sardines are migratory in their habits, and the exact *locale* of their winter quarters, despite frequent research on the point, remains a mystery. In ordinary years it is the custom for the fish to make their first appearance on the coast of Africa about the end of March, then passing northward in large shoals they follow the coast of Portugal crossing the Bay of Biscay, till they strike the coasts of Vendée in the month of April or May. Before daybreak the fishing-boats leave port to search for the shoals of sardines: indeed, many leave in the evening and anchor at sea. When a peculiar bubbling of the water reveals the fish, the nets are immediately thrown. Each net is from 900 to 1000 yards in length, about 3 yards in width, and black in colour. On the upper part of the net are corkfloats, and on the lower part leaden sinkers to keep the net in an upright position. The oarsmen, generally two in number, row always either against the wind or the tide. One man casts the net as the boat advances, while another throws the *rogue* into the water. This bait is an important feature of the sardine catch, as it is expensive, and fishermen often lose considerable quantities of it. It is made of the roe of cod-fish or mackerel mixed with clay, and costs from 30s. to £3. 10s. a barrel, and it is thrown into the water in small balls which slowly dissolve and sink. At nightfall the boats return to port, where they sell their fish to the canners at prices varying according to the abundance of the catch and the size and freshness of the fish. Sales are made by the 'thousand,' but this term does not always indicate exactly a thousand sardines. For example, at Belle Isle 1240 fish are supposed to make a thousand. Factories for preserving sardines are located at all the ports, for the fish spoil easily and cannot bear transportation. The fishermen convey the sardines to the factories in baskets. The process of canning is as follows:—The sardines are spread on boards and salted, and the heads removed. They are then thrown into brine, where they remain half an hour. They are next washed in clean water and dried on screens. This work is done almost entirely by the wives and children of the fishermen, their united wages during the season enabling the family to subsist during the following winter. After the fish have been thoroughly dried they are cooked by dipping them for a few minutes in oil heated to 212° F. They are again drained and handed over to workmen, who pack them in small tin boxes which are filled with pure olive oil and then soldered. The oil used is imported from the province of Bari, Italy. The boxes are next thrown into hot water, where they remain for two or three hours, according to the size of the boxes. When withdrawn the boxes are first cooled, then rubbed with sawdust to cleanse and polish them, and packed in wooden cases of one hundred boxes for export; during their immersion in the boiling water oil will escape from all boxes not properly soldered, and in such cases the loss is sustained by the solderer, but so skilful are those in the craft that a good workman rarely misses more than two or three boxes per hundred. Periodically the fish entirely disappear for a season or so from the coasts of Spain, France, and Italy."

Fresh Water Herrings Especial interest attaches to the Australian fresh-water herrings (*Diplomystes*), which differ from the typical genus in having a series of bony plates similar to those on the lower surface between the back of the head and the dorsal fin, since a similar type of fish has been long known in a fossil state, having been obtained from the Cretaceous rocks of Brazil and Syria, and the Lower Tertiary of the United States and Britain. The persistence at the present day of this ancient type of herring in the fresh waters of Australia is an instance of the survival of primitive forms of life in that region.

Anchovies. The common anchovy of the Mediterranean (*Engraulis encrasicholus*) is the typical representative of a second widely-spread genus, with over forty species, differing from the last by the more or less nearly conical muzzle projecting beyond the lower jaw, and also by the eyes being covered with skin; while the cleft of the mouth is deep, and the tail-fin forked. In most cases each side of the body is ornamented with a broad longitudinal silvery stripe. The common anchovy is met with off the south-western coasts of England, but wanders still further to the north, and serves to supply the markets of the world. Some species have the rays of the pectoral fins produced, and thus lead on to the allied Oriental genus *Coilia*, in which the foremost rays of these fins are filamentous, and the exceedingly long anal fin extends backwards to join the caudal.

Elops. A very distinct group, which, as already mentioned, is regarded by some as a distinct family, is typically represented by the two species of the tropical and subtropical genus *Elops*. In addition to the characters of the skull noticed in p. 487, these fish have the lower jaw longer, a thin plate of bone extending backwards from the point of union of the two branches of the lower jaw, and the whole under surface of the body smooth and rounded. The common species grows to a yard in length. An allied type (*Rhacolepis*) occurs in the Cretaceous rocks of Brazil.

Slender-Scales. The earliest allies of the herring tribe seem to be the extinct slender-scales (*Leptolepididæ*), of which there are a considerable number of species ranging throughout the Jurassic period. In the typical *Leptolepis* the dorsal fin is placed immediately over the pelvic pair, but in the nearly allied *Thrissops* it is over the anal. Although there are a number of other extinct generic types, more or less closely related to the herrings, it is impossible to enter into their consideration here, and we accordingly pass on to

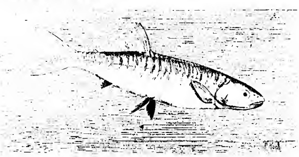


BLACK SMOOTH-HEAD (1/10th nat. size).

THE SMOOTH-HEADS AND SOUTHERN SALMON.

Families ALEPOCEPHALIDÆ and HAPLOCHITONIDÆ.

Smooth-Heads. The first of these two families is typically represented by the genus *Alepocephalus*, of which a species (*A. niger*) is shown in the annexed illustration. While agreeing with the typical salmonoids in the structure of the skull and the presence of two true tail-vertebræ, as well as in other features, these fish may be distinguished by the absence of the fatty fin. Whereas barbels are invariably absent, and the head is always naked, the body may be either scaled or bare. Both premaxillæ and maxillæ enter into the formation of the margin of the upper jaw, the former occupying the upper front edge of the latter. All the elements of the gill-cover are present; the dorsal fin is situated opposite the anal in the caudal region; the gill-openings are very wide; false gills are present; the air-bladder is wanting; and the curved stomach has no blind appendage. All these fish have the teeth feebly developed, the eye large, and the bones thin; while they are remarkable for their uniformly black coloration. The whole of them are deep-sea fishes, with an apparently almost cosmopolitan distribution, some of them having been taken at a depth of over two thousand fathoms. Whereas the body of the typical genus is covered with thin cycloid scales, in another type the place of these is taken by fine granules.



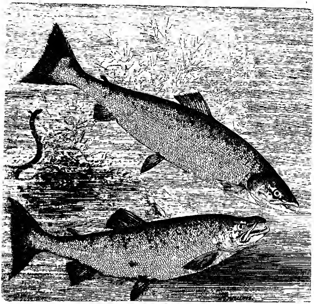
ZEBRA-SALMON.

Southern Salmon.

By this name may be designated two genera of fresh-water fish, constituting a family which represents the salmonoids in the Southern Hemisphere; the zebra-salmon (*Haplochiton zebra*) being figured as an example of the typical genus. Like the salmon and herrings, devoid of barbels, these fish agree with the former in the presence of a fatty fin, but differ in having the margin of the upper jaw formed solely by the premaxillary bones. The body may be either naked or covered with scales; the gill-opening is wide; false gills are present; and the air-bladder is simple. The ovaries are in the form of plates, and, in the absence of a duct, the eggs fall into the abdominal cavity. The species of the typical genus, which, although devoid of scales, are externally very similar in appearance to trout, are confined to the lakes and rivers of Chili and the extreme south of Patagonia and the Falkland Islands. In South Australia and New Zealand the family is represented by the genus *Prototroctes*, in which the body is scaled and the jaws are armed with minute teeth; the New Zealand species being commonly known to the colonists as the grayling.

The Salmon Tribe,—Family *Salmonidæ*

With the salmon tribe, which include the finest and "gamest" of all fresh-water fish, we come to the last group of the true bony fishes, which may be distinguished from the preceding family by the margin of the upper jaw being formed by the premaxillæ in front and by the maxillæ at the sides. As a rule, the body is scaled, while the head is invariably naked; the under surface of the body being rounded.



SALMON AND SEA-TROUT ($\frac{1}{8}$ nat. size).

Inhabiting alike salt and fresh-waters, those species which spend a part or the whole of their existence in rivers or lakes are in the main confined to the Temperate and Arctic zones of the Northern Hemisphere, although one outlying genus occurs in New Zealand; and whereas the majority of the marine forms are deep-sea fishes, two genera are entirely pelagic in their habits. A considerable number of the species inhabiting fresh waters descend periodically or occasionally to the sea; and in some cases it is perhaps rather difficult to say whether these fishes should be regarded as marine or fresh-water. All the salmonoids are remarkable for the excellent quality of their flesh, which in many forms is of a more or less strongly marked pinkish hue, brought about by the crustaceans on which these carnivorous fishes so largely feed. Fossil marine salmonoids, some of which belong to existing genera, are known from the upper Cretaceous period, several of them apparently connecting the family very closely with the herrings. As mentioned above (p. 487) the more typical members of the family have the parietal bones of the skull separated from one another by the supraoccipital, but in *Coregonus* and *Thymallus* they unite together in front of it. There is, however, a genus (*Stenodus*) in which both conditions exist, so that there is no justification for making the union of the parietals a reason for referring *Coregonus* to a family apart. In all cases the supraoccipital extends forwards to join the frontals (passing beneath the parietals in the genera where those unite), and is thus quite different from the condition obtaining in the carps and characinoids.

Typical Group

Having the dorsal nearly or quite opposite the pelvic fins, the members of the typical genus *Salmo* are characterised by the small size of the scales of the body, the strong and fully developed teeth, and the presence of not more than fourteen rays in the anal fin, and of numerous blind appendages to the intestine. The cleft of the mouth is always deep, the maxilla extending up to or beyond the line of the eye. Conical teeth are present not only in the margins of the jaws but likewise on the vomer and palatine bones, as well as on the tongue, although there are none on the pterygoids. The eggs are remarkable for their relatively large size; and the young, like those of most or all the other genera, are marked with dark crossbars. In the males the lower jaw is more developed than in the females, and at certain seasons may be developed into an upturned hook. The genus is confined to the colder portions of the Northern Hemisphere, its southern limits in the Old World being the rivers of the Hindu Kush and the Atlas range, and in America the rivers flowing into the head of the Gulf of California.

Few zoological subjects have given rise to a greater amount of discussion than the life history of the members of this genus, and the number of species by which it is represented. As regards the latter point, great difference of opinion still prevails among experts. Thus, for instance, Day considered that all the indigenous British salmonoids might be arranged under three specific types, namely, the salmon, the trout, and the charr; while other authorities admit an almost endless amount of species. The subject is not one which admits of discussion in this work, and we shall accordingly confine our notice to the salmon, the typical sea- and river trout, and the charr. As regards the variability of these fishes we may, however, quote a passage from Dr. Gunther, who writes that "these are dependent on age, sex, and sexual development, food, and the properties of the water. Some of the species interbreed, and the hybrids mix again with one of the parent species, thus producing an offspring more or less similar to the pure breed. The coloration is, first of all, subject to variation; and consequently this character but rarely assists in distinguishing a species, there being not one which would show in all stages of development the same kind of coloration. The young of all the species are barred; and this is so constantly the case that it may be used as a generic, or even as a family character, not being peculiar to *Salmo* alone, but also common to *Thymallus* and probably to *Coregonus*. The number of fins is not quite constant, but the migratory trout have two (and even three) more than the river-trout. In some waters river-trout remain small, and frequently retain the parr-marks all their lifetime; at certain seasons a new coat of scales overlays the parr-marks, rendering them invisible for a time. When the salmonoids have passed this 'parr' state, the coloration becomes much more diversified. The males, especially during and immediately after the spawning-time, are more intensely coloured and variegated than the females; specimens which have not attained to maturity retaining a brighter silvery colour, and being more similar to the female fish. Food appears to have much less influence on the coloration of the outer-parts than on that of the flesh; the more variegated specimens being frequently out of condition, whilst well-fed individuals with pinkish flesh are of a more uniform, though bright, coloration . . . . The water has a marked influence on the colours; trout with intense ocellated spots are generally found in clear rapid rivers and in small open Alpine pools; in the large lakes with pebbly bottom the fish are bright silvery, and the ocellated spots are mixed with or replaced by X-shaped black spots; in pools or parts of lakes with muddy or peaty bottom, the trout are of a darker colour generally; and when enclosed in caves or holes, they may assume an almost uniform blackish coloration." A change of colour also takes place in the migratory species with the renovation of the scales, which occurs during their residence in the sea, the newly grown portion of the silvery scales concealing the spots; and this change of coloration varies greatly according to the habitat of the individuals of some of the species. Variations of size are also common, these being for the most part dependent upon the abundance or otherwise of the food and the extent of the area in which the fish dwell; but differences in this respect also occur among the fish hatched from the same batch of spawn, and living under the same conditions. The variations in the form and proportions of the body and more especially in the head and jaws, according to age, sex, and season, are likewise very important, but cannot be noticed fully.

Salmon

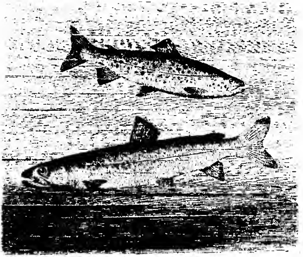
The true salmon (*S. salar*), together with the kindred species and the trouts, belongs to a group of the genus characterised by the presence of teeth on the whole length of the vomer during at least some period of life. In the case of such a well known fish—and also one which is generally pretty easy to distinguish from its congeners—it will be unnecessary to give a description. Dr. Gunther gives, however, certain characters by which this fish may always be identified, and among these the following may be noticed. The scales on the tail are of relatively large size, and each transverse series running from behind the fatty fin towards the lateral line contains only eleven, or occasionally twelve, whereas in the trouts there are from thirteen to fifteen. Secondly, the main part or body of the vomer carries a single series of small teeth, which, with advancing age, gradually disappear from behind forwards, so that half-grown and adult individuals have but a few remaining. Having a circumpolar distribution, the salmon ranges southwards in America to 41° north latitude and in the Old World to 43°, being unknown in any of the rivers flowing into the Mediterranean. Salmon will grow to a length of between 4 and 5 feet, and commonly reach as much as 40 lbs. Much heavier fish are, however, occasionally captured. Among these may be mentioned a salmon of 60 lbs from the Severn in 1889; one from the

Tay of 62 lbs. in 1891; a third of 63 lbs. from the Esk in 1890; another of 68 lbs. from the Tay in 1893; and a fifth from the same river taken in 1870, which weighed a fraction under 70 lbs. There is an earlier record of a British salmon of 83 lbs. weight, while a Russian is stated to have scaled upwards of 93 lbs.

For the following brief sketch of the life-history of the salmon, we are indebted to a paper by Mr. G. Rooper, from which the following extracts, with some verbal alterations, are taken. After mentioning the well-known periodical migration of salmon, the writer observes that the eggs are deposited by the female some time during the winter months in beds of gravel over which a rapid stream flows principally in the upper reaches of the river, where the water is more aerated and free from pollutions of any sort—since clay, earth, or any extraneous substance would choke and destroy the embryo fish. Indeed, from the time of entering the river the object of the fish seems to be to arrive at its source. Until they have spawned they never descend, but, resting at times in favourite pools, continually struggle upwards. Only the late fish spawn in the lower waters. To such as have only seen the salmon in prime condition, the appearance of the fish when on the eve of spawning would come as a surprise. The female is then dark in colour, almost black, and her shape sadly altered for the worse from that which she presented when in condition. As for the male, he is about as hideous as can well be imagined, his general colour being a dirty red, blotched with orange and dark spots. His jaws are elongated, and the lower one furnished with a huge beak, as thick and nearly as long as a man's middle finger; while his teeth are sharp and numerous, and his head, from the shrinking of the shoulders, appears disproportionally large. His skin also is slimy and disagreeable to handle, and, in fact, scarcely a more repulsive creature in appearance exists. Arrived on the spawning-ground the female, then called a baggit, alone proceeds to form the nest, or 'redd' as it is termed. This she effects by a sort of wriggling motion of the lower part of her body working on the loose gravel. Many authors state that this is effected by the action of the tail, but I think the convex formation of the body at that period would prevent the tail touching the gravel, unless the fish stood at an angle of 45°, in which case the stream would carry her down. The redd, a deep trench, being formed, the female proceeds, attended by the male fish—frequently by two kippers, as they are then called—to deposit her eggs. This she does, not all at once, but in small quantities at intervals, frequently returning to the redd for the purpose. The eggs are at once fecundated by the milt of the kipper; this process going on for two or three days, the fish sinking down occasionally into the pool below to rest and recover their strength. The effect of the fertilisation of the ova is to add greatly to their specific gravity; the eggs sink, and are at once covered with gravel by a similar motion on the part of the baggit to that used in the formation of the redd. Here, the process being completed, the eggs remain during a period of from one hundred and twenty to one hundred and forty days, according to the temperature of the water. At the expiration of that time the little fish come into existence, and, after a few days, wriggle out of their gravelly bed and seek refuge under an adjacent rock or stone, where they remain in safety for some twelve or fourteen days longer. The appearance of the young fish at that time gives little promise of the beautiful form to which they subsequently attain. They are indeed shapeless little monsters, more like tadpoles than fish, each furnished with a little bag of nutriment forming a portion of the abdomen. On this, for two or three weeks, they subsist, until it is absorbed, when they take the form of fishes. They are then about 1 inch in length, and are known as salmon-fry or samlets. A portion of the eggs are washed down the stream during the process of spawning, and become the prey of trout and other fish which attend the redds for the purpose of feeding on them. In this they do no harm whatever, for these eggs, being uncovered and unfecundated, could never arrive at maturity. The kippers, when not actually engaged in the spawning process, swim rapidly about the redd, fighting fiercely with one another. The use of the beak appears then to come into operation. Many authors erroneously describe this beak either as a weapon of offence, or as a sort of pickaxe used in digging out the redd; but it seems to me that nature has provided this singular excrescence as a protection and safeguard against the savage attacks made on each other. So large is its size, and so closely does it fit into the hole or socket formed in the upper jaw, that it would appear almost impossible for the fish even to open his mouth; but he does so, to some extent at least, and with its cat-like teeth inflicts deep, and sometimes dangerous wounds on his antagonists. As to its alleged use as a digging implement, the substance of the beak is cartilaginous, not horny, and by no means hard; it would be worn down in the process of digging in ten minutes, and, moreover, the female alone prepares the redd. After leaving the stone or rock under which it has sought protection, the young fish grows very rapidly, as is natural in one destined to attain such huge dimensions as the salmon. In the course of a month or six weeks the fry have attained to the length of 4 inches, and are then called 'parr', when they bear conspicuously on their bodies transverse marks or bars, which are common to the young of every member of the salmon family. Unfortunately, there is another little fish, a humble relation of the lordly salmon, also barred, very similar in appearance, which too is called a parr, and the identity in name and similarity in appearance has occasioned great confusion and controversy, especially as they are inhabitants of the same waters and affect to some extent each other's company. The time of their remaining in the parr stage is also a subject of dispute; and while some say two, three, or sometimes four years, my opinion is that they remain one year only. In the second April of their existence a change in the appearance of the parr occurs, which assumes the silvery scales of the adult fish, wearing his new apparel over his old barred coat. He is now called a 'smolt,' and perhaps, with a wish to exhibit himself in his new and beautiful apparel, evinces a daily increasing restlessness and desire to quit his home. With the first floods in May myriads of these lovely little fishes start on their downward journey toward the sea. It is a beautiful sight to watch their movements when descending; and for many days the river teems with them, not a square foot of water being without one when the stream is at all rapid. As fry the smolts were exposed to many dangers, but they were nothing to those which beset them as parrs on their journey towards the sea. Their enemies are legion. Trout and pike devour them, gull swoop down and swallow them wholesale. Herons, standing mid-leg deep in the water, pick them out as they pass; and even their own kindred devour them without scruple. Unluckily, too, for them, a certain number of great, hungry kelts (as the fish are called after spawning), having recovered to a great extent their condition, accompany them on their seaward journey, and prey upon their young companions as they travel, and I believe that a hungry kelt will devour upwards of forty or fifty smolts in a day. Arrived at the sea, the little fish are met by a fresh array of enemies. The army of gulls is always with them, and these are reinforced by cormorants, divers, and other sea-birds, besides which shoals of ravenous fish await their arrival, and assist in thinning their ranks. It is wonderful that any should escape, and but for the extraordinary fecundity of the salmon, they would speedily be annihilated; but such is their prolific nature that a remnant always survives to return to the spawning-beds and keep up the supply. Buckland calculated that the number of eggs laid by a salmon was about one thousand to the pound weight, a fish of 15 lbs. therefore producing fifteen thousand eggs. The food of the smolt during his sojourn in the sea is abundant, consisting chiefly of sand-eels, molluscs, and marine insects. The smolts increase accordingly very rapidly in size, and in three or four months the fish that came down 5 or 6 ounces in weight returns to the river from whence he came, a grilse of from 4 to 6 lbs.; the grilse being the fifth stage of the salmon's existence. Unless accidentally prevented the grilse always returns to the river from whence it came, and after spending the autumn and winter at home, and providing for the continuance of the family by spawning as already described, returns as a kelt to the sea in the following year, reappearing the next as a salmon of at least 10 or 12 lbs. weight. It should be added, that after spawning the fish speedily recover their colour, and to a great extent their condition; the baggit at once losing her dark complexion, and the kipper discarding his hideous livery, his great beak being rapidly absorbed, his sides becoming silvery, and his back assuming a dark bluish tinge."

With reference to the statement in this account that salmon always return to the river of their birth, it may be observed that although this is generally the case, the circumstance that salmon occasionally make their appearance at the mouth of the Thames and other rivers which they have ceased to inhabit, shows that there are exceptions to the rule. The obstacles that salmon will surmount in their ascent of rivers during the return from the sea are too well known to require notice; but it is probable that the height to which they can leap has been exaggerated. The period of spawning varies with the country, taking place in the south of Sweden and North Germany at the latter part of October or early in November; while in Denmark it may be deferred till February or the beginning of March. November and December being the usual spawning months in Scotland.

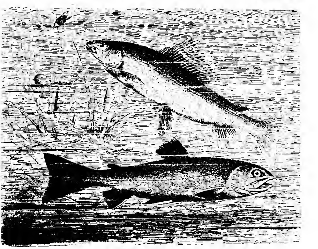
Trout. In spite of their diversity of habitat, and likewise of coloration and structure, Day is of opinion that the migratory sea-trout, or salmon-trout (*S. trutta*), and the stationary river-trout (*S. fario*), as well as the various forms from the British lakes, are nothing more than varieties of a single variable race; and it must be confessed that no one has hitherto been able to define all the nominal British species with anything like definiteness. Still, however, in the modern sense of the words there is no possibility of drawing a hard-and-fast line between a species and a variety; and the question is accordingly of no very great importance one way or another. Some of the characters distinguishing the salmon from the trout have been already indicated on p. 494; and it will suffice to note very shortly some of the reasons given by Day for regarding all the British trout as referable to a single species. It is well known that sea-trout—as represented not only by the typical form, but likewise by the so-called sewen (*S. cambricus*) of the Welsh rivers—are silvery in colour, with black spots during their sojourn in the sea; when, however, they enter the rivers for the purpose of spawning, an orange margin appears on the upper and lower edges of the caudal,



SEA-TROUT AND HUCHO ($\frac{1}{8}$ nat. size).

and likewise on the fatty fin, while spots of the same colour show themselves on the body. On the other hand the nonmigratory forms may be arranged under two types of coloration, some loch-trout (which may have been originally migratory, but are now landlocked) being mainly silvery during the smolt-stage, and subsequently golden and spotted; while the estuarine, lake, and river-trout are all golden, with purplish reflections and more or less fully marked with black and vermilion spots. It appears, indeed, that a long residence in fresh water generally leads to the disappearance of the silvery sheen characteristic of the salmonoids while in the sea (and which is probably their primitive type of coloration), and to the promotion of colour. As a partially transitional type between sea-trout and river-trout may be taken the Lochleven trout, which is somewhat silvery during the smolt-stage, with the spots generally black, and no orange border to the fatty fin, but at a later stage assumes the general coloration of the river-trout, although lacking the white black-based front margin to the dorsal, anal, and pelvic fins characteristic of the latter. Silvery trout do, however, occasionally occur in fresh waters, where there is no possibility of their having migrated from the sea. In concluding his observations concerning the coloration of trout, Day writes that "reasons have been shown for admitting that sea-trout might breed in fresh waters without descending to the sea. That they can be traced step by step and link by link, into the brook-trout, and *vice-versâ*; that the Lochleven trout, which normally possesses a smolt- or grilse-stage, passes into the brook-trout; and also that breeding any of these two forms together sets up no unusual phenomena." Later on, he observes that some of the chief distinctions between the sea- and fresh-water forms of trout consist in the comparatively more complete system of dentition in the fresh-water races, their generally longer head, blunter muzzle, and stronger upper jaw, irrespective of the smaller number of blind appendages to the intestine. The dentition is, however, excessively variable; and specimens with the coloration and form of the river-trout taken in estuaries, or even in the sea, usually have the small number of vomerine teeth characteristic of the migratory forms; while, on the other hand, fresh-water examples with the coloration of the migratory type may have a dentition of the nonmigratory type. "It has been asserted that brook trout invariably have a double row of teeth along the body of the vomer, and some authors have gone so far as to assert that these teeth are not deciduous. Doubtless it is not uncommon to find trout up to 2 lbs. weight, or even more, with all the vomerine teeth thus remaining intact when a double row is present; but it is by no means rare to see only one irregularly-placed row, while in very large specimens these teeth (unless they have entirely disappeared) are always in a single row, and the vomer may be found toothless, or with only one or two teeth at the hinder edge of the head. Equally incorrect is the statement that the teeth disappear differently in different forms, for in all they first assume a single row, and then fall out, first commencing from behind. But in the rapidly growing sea-trout the vomerine teeth are shed sooner than in the brook-trout." The limits of our space preclude our entering further into the consideration of this interesting subject. The ordinary sea-trout, which is essentially a North European fish, much more common in Scotland than in England, and grows to a length of 3 feet, is depicted in the lower figure of the illustration on p. 493; while, as an example of a spotted form, we take a variety of the Continental lake-trout (*S. lacustris*), shown in the upper figure of the illustration on p. 499. Known on the Continent as the *maiforelle* (May-trout), this fish has the sides of the body marked with irregular angular or X-shaped black spots, between which are red spots, these spots becoming less numerous beneath the lateral line, while the under surface may be tinged with red. On the gill-cover the spots are larger and more rounded. In the typical variety of this trout, from the Lake of Constance, the spots do not extend below the lateral line; this form being known as the *schwebforelle*. The migrations of the sea-trout are very similar to those of the salmon; in Sutherland the great run of these fish to the sea taking place in June, while they reascend the rivers in autumn to spawn. Jardine writes that "in approaching the entrance of rivers, or in seeking out, as it were, some one they preferred, shoals of this fish may be seen coasting the bays and headlands, leaping and sporting in great numbers, from 1 to 3 or 4 lbs in weight; and in some of the smaller bays the shoals can be traced several times circling it, and apparently feeding." On the other hand, the Continental May-trout spends the colder months in the deepest waters of the mountain-lakes, only coming to the surface in May. During the summer these trout may be seen swimming round the shoals of small fishes on which they prey until they get them well together, when they make a sudden rush among them.

Charr Much the same difference of opinion as obtains with regard to the number of species of trout exists in the case of charr,



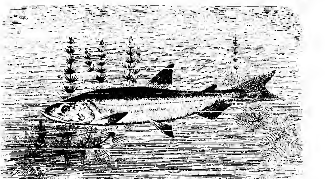
GRAYLING AND CHARR (¼ nat. size).

Dr. Günther recognising five British lacustrine species, which he regards as distinct from *S. umbla* of the Swiss lakes; while Day includes the whole of these under the latter, which is also taken to embrace the sæbling (*S. salvelinus*) of the mountain-lakes of Bavaria and Austria, as well as the migratory northern charr (*S. alpinus*), ranging from Lapland and Scandinavia to Iceland and the northern parts of Scotland. All charr differ from salmon and trout in having the teeth at all ages confined to the head of the vomer, instead of being distributed over its whole length; and all the forms mentioned above, which have a very uniform type of coloration, agree in having median teeth on the hyoid bone. Without committing ourselves definitely, we confess that we are inclined to agree with Day as to the specific identity of the whole of them. To illustrate the group, we have the saibling depicted in the lower figure of the illustration on p. 501. In the spawning-season the upper-parts of this fish are brownish green, and the sides lighter, the under surface passing through all shades of orange to vermilion, from the throat to the pelvic fins, where the colour attains its greatest intensity. The sides are ornamented with rounded spots varying from white to red in colour; the dorsal fin has dark markings, and the pectoral and pelvic fins are brilliant red. This form commonly grows to a length of 8 or 9 inches, but the northern charr attains much larger dimensions. Day writes that "the colours of the British charr do not vary to so great an extent as in the trout, owing to their residing in deeper waters, and usually merely ascending towards the surface at night-time to feed, while other changes in tint are consequent upon the breeding-season. In the Lakes of Cumberland, Westmoreland, and Lancashire this fish in its ordinary state is the case-charr of Pennant; when exhibiting the bright crimson belly which it assumes before spawning, it is called the red charr; when out of season, the spawn having been shed, it is distinguished by the name of the gilt charr. . . . Charr are a more delicate and apparently shorter-lived fish than trout, requiring deeper and stiller pieces of water, and a colder temperature; they have even been recorded as residing in lochs where the sun never reaches the surface of the water. They are readily destroyed by poisonous substances; while attempts to introduce them to fresh localities have not been so uniformly successful as with the trout."

The North American charr (*S. fontinalis*), which has been successfully introduced into British waters together with the hucho (*S. hucho*) of the Danube, differ from the foregoing in the absence of median teeth on the hyoid bone; the latter fish being shown in the lower figure of the illustration on p. 499. The general colour of the American charr is greenish,—lighter above than beneath,—beautifully shot with purple and gold, ornamented with numerous dark spots above, and fewer below the lateral line, many of which in front of the dorsal fin coalesce into streaks; and also with red spots above the aforesaid line. Most of the fins have dark markings; and in the breeding-season the male assumes a black line along the under surface. These fish usually range in size from 2 to 3 lbs., although they may be larger. The hucho, on the other hand, which is readily characterised by its elongated, slender, and almost cylindrical form, attains dimensions equal to those of the salmon.

Many-Rayed Salmon. A group of migratory salmonids (*Oncorhynchus*) inhabiting the North American and Asiatic rivers flowing into the Pacific differ from the typical genus in having more than fourteen rays in the anal fin; while their kelts are remarkable for the degree to which the jaws are hooked, and the humping of the back. An early writer in describing the hordes in which these salmon annually visit Kamschatka, states that they "come from the sea in such numbers that they stop the course of the rivers, and cause them to overflow the banks; and when the waters fall there remains a surprising quantity of dead fish upon the shore, which produces an incomparable stink; and at this time the bears and dogs catch more fish with their paws than people do at other places with their nets." Dr. Guillemard adds that "every year the various kinds of salmon arrive at the mouths of the Kamschatkan rivers with surprising regularity. The date of the advent of these different species extends from May to mid-August; but each has its own time of arrival, which, from its constancy, appears to be more or less independent of seasonal influences. A few fish apparently remain at or about the river mouths during the summer, and eventually return to the sea, but these are so few as to be scarcely worthy of mention. The vast majority—practically all, in fact—ascend the streams to spawn, and, having once done so, die. In the case of some species every fish appears to perish; in others, a few get back to the sea." The Oriental salmon (*O. orientalis*) of Kamschatka commonly grows to a weight of from 50 to 60 lbs., and the flesh is said to be superior in flavour to that of any other member of the family.

Smelts. The beautiful and delicately flavoured little fish known as smelts are represented by three species, one of which (*Osmerus eperlanus*) is an inhabitant of the seas and many fresh waters of Northern and Central Europe, while the second (*O. viridescens*), which is perhaps only a variety, is confined to the opposite side of the Atlantic, and the third (*O. thaleichthys*) is found on the coasts of California. These fish form a kind of connecting link between the salmon and its allies and the under-mentioned *Coregonus*, but internally differ from both, the appendages to the intestine being short and few in number, and the eggs small, while the teeth are strongly developed. The scales are of moderate size; the cleft of the mouth is wide, with the maxillary bone extending nearly or quite to the hinder margin of the eye; the teeth of the upper jaw are much smaller than those of the lower; the vomer is armed with a transverse series of teeth, several of which are tusk-like; the palatines and pterygoids bear conical teeth,

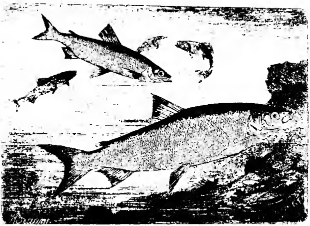


COMMON SMELT ([illegible] nat. size.)

while there are also tusk-like teeth on the front of the tongue, and several longitudinal series of small ones on the hinder part of the same. In length the pectoral fins are medium. Growing to a length of 7 or 8 inches in the sea, the common smelt is also found in rivers and landlocked lakes, where its size is always considerably less. The [illegible] candle-fish (*Thaleichthys*) of the Pacific coasts of North America, distinguished by its rudimental teeth, has flesh of such an oily nature that it can be burnt as a candle, although it is likewise used as food.

Coregonoids For want of a collective English name, we must allude by a modification of their Latin title to an extensive group of mostly fresh-water salmonoids, among which the powan (*Coregonus clupeoides*), the vendace (*C. vandesius*) of Lochmaben and the pollan (*C. pollan*) of the Irish lakes are well-known British forms. In these fish the scales are not strikingly large; the cleft of the mouth is of moderate size, with a broad maxilla, either short or of medium length, and not extending beyond the front margin of the socket of the eye; while the teeth if present at all are minute and deciduous, in the adult usually remaining only on the tongue. The dorsal fin is not over long, and the caudal is deeply forked. Whereas in the small size of their eggs these fish resemble the smelts, they differ in having about one hundred and fifty blind appendages of nearly uniform length attached to the intestine. As already mentioned, these fish differ from the typical salmonoids in the relations of the bones on the top of the skull, on which account they are regarded by Professor Cope as indicating a separate family. Represented by over forty species, ranging over Northern Temperate Europe, Asia, and North America, coregonoids are for the most part entirely fresh-water fishes, although a few make periodical migrations to the sea, while the European schnapel (*C. oxyrhynchus*) is as much a marine as a fresh-water fish. Local in their distribution in Europe, although as many as three different species may inhabit the same lake, coregonoids are extremely abundant in all the fresh waters of North America (where they are commonly known by the name of white-fish); and whereas all the British forms are small, some of the continental species may attain a length of fully two feet. The genus may be divided into groups, according to the conformation of the muzzle and jaws. Of these, the first is represented solely by the schnapel (*C. oxyrhynchus*), which frequents the coasts and rivers of Belgium, Holland, Germany, and Sweden, and occasionally wanders into British waters. It is easily distinguished by the production of the extremity of the upper jaw into a conical fleshy snout projecting beyond the lower, while its scales are more or less nearly circular. In length this fish grows to a foot and a half. As an example of the group in which the muzzle is obliquely truncated, with the nose projecting, we may take the marane (*C. lavaretus*), shown in the lower figure of our illustration, this fish being widely distributed in the lakes of the Continent, where its flesh is highly esteemed as food. Whereas in the Austrian lakes this fish does not exceed 14 or 15 inches in length, with a weight of half a pound, in Lake Constance it grows to a couple of feet in length, and from 4 to 6 lbs. in weight. Living at great depths, this fish feeds on worms, insects, and water-snails. While the powan belongs to another group characterised by the vertical truncation of the muzzle, the pollan and vendace are assigned to yet another division in which the lower jaw is longer than the upper.

into a shallow notch of which it is fitted. As a representative of this latter group we take the pigmy marane (*C. albula*) of Northern Europe, shown in the upper figure of the illustration. Pollan, which grow to a length of about 6 inches, are largely sold in Belfast during the spawning-season, at which time they come up from the deep waters of Lough Neagh to the shallows. At times they occur in enormous numbers, upwards of seventeen thousand having been taken on one occasion in the early part of this century.



PIGMY MARANE AND MARANE ([illegible] NAT. SIZE).

Grayling. The last of the salmonoids that we have space to notice are the grayling, of which the European species (*Thymallus vulgaris*) is shown in the upper figure of the illustration on p. 501. Nearly allied to the coregonoids, the grayling are readily distinguished by the greater height and length of the dorsal fin, which includes from thirteen to twenty-three rays. The cleft of the mouth is also smaller, and the maxilla of small size. Small teeth are present in the jawbones, as well as on the palatines and the head of the vomer, but they are wanting on the tongue. The blind appendages of the intestine are less numerous than in either the salmon or the coregonoids, and the air-bladder is unusually large. The range of the genus includes a large portion of Europe, Northern Asia, and the colder regions of North America. The common species is found locally over a great part of Europe, ranging from Lapland to Venice, and from England to Russia. It is, however, unknown in Ireland, and has only been introduced of late years into Scotland; while in England it is most abundant in the rivers flowing from the limestone Pennine chain in the north, and the Red

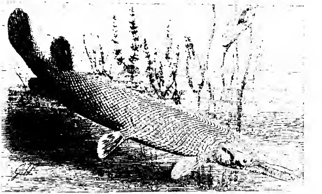
Sandstone districts of the central counties, and likewise in the chalk streams of the south. In the latter area grayling occasionally run to nearly 4 lbs in weight, but in Northern Scandinavia they may reach 1 lb more. In Switzerland they are found in Lake Constance and other large pieces of water. An elegantly-shaped fish, the grayling varies considerably in colour according to the season of the year, the back being generally greenish brown, passing into grey on the sides, while the under parts are silvery. The sides of the head are yellow, with black spots, which also occur on the fore-part of the body; and brownish grey longitudinal stripes run in the direction of the rows of scales. The pelvic and anal fins are violet, frequently marked with brown crossbars; the pectorals are yellow, turning to red in the breeding-season; while the black-bordered dorsal and caudal are generally red, although sometimes blue, the former, and sometimes also the latter, being ornamented with longitudinal dark bands or rows of spots. A second species, with smaller scales, inhabit the mountain streams of Dalmatia, but the other two are North American.

Percopsis A remarkable fish from the fresh waters of the United States known as *Percopsis guttata*, which has the general characters of a salmonoid but the mouth and scales of a perch-like type, is regarded as representing a family (*Percopsidae*) by itself, nearly allied to the salmon tribe.

The Bony Pike and its Kindred.—Suborder Ætheospondyli

The remaining groups of the Teleostomous fishes exhibit a more or less decidedly lower type of organisation than those described above; and, although the sturgeons are still well represented, these groups as a whole are evidently waning ones at the present day, having only very few living forms, whereas in past epochs some of them formed the dominant types in the fish-fauna of the world. The bony pikes of the fresh waters of North America constitute a family (*Lepidosteidae*) which forms the sole existing representative of a distinct suborder. While agreeing with the preceding suborders in the divisional characters mentioned on p. 334, the members of this group and the next exhibit much more marked differences from all the foregoing groups than do the latter from one another. With the exception of the extinct spear-beaks, the tail is of the abbreviated heterocercal type; that is to say, that while its fin is more or less nearly symmetrical, the vertebral column, which retains its primitive tapering extremity, runs in the upper half. The scales are ganoid, and very frequently quadrangular, although they may be rounded and distinctly overlapping. In the living representatives of both suborders the air-bladder is connected with the œsophagus by a duct, in the same manner as in the tube-bladdered fishes; but the optic nerves simply cross one another, without any interlacing of their fibres, and there is a spiral valve to the intestine. Whereas with the exception of one extinct group of herrings, the whole of the suborders of bony fishes hitherto noticed are unknown previous to the Cretaceous epoch, members of the two groups to be now considered were abundant in the antecedent Jurassic period. The group including the bony-pike may be distinguished from the next by the full ossification of the internal skeleton; the scales being always of the typical quadrangular ganoid type and the branchiostegal rays having no gular plate in advance of them.

Existing Family. As a family, the bony-pikes, of which the common species (*Lepidosteus osseus*) is shown in our illustration, are distinguished from all other fish by having the bodies of the vertebræ convex in front and concave behind, instead of having both surfaces cupped. The fins are furnished with fulcra, the dorsal and anal consisting of soft rays only, and placed far back, and near the caudal, which is of the abbreviated heterocercal type; while the trunk is much longer than the abdominal portion of the vertebral column, and the branchiostegal rays are comparatively few, and have not an enamelled outer surface. In form, the body of the bony-pikes is elongate and subcylindrical; the long muzzle is either spatulate or beak-shaped; the cleft of the mouth wide; and both the palate and jaws are armed with bands of rasp-like teeth, and also with larger conical ones. There are four gills and three branchiostegal rays on each side; and the air-bladder is cellular. Bony-pike, of which there are three existing species, are now confined to North and Central America and Cuba; but they are represented in the European Eocene, and by allied extinct genera in the Eocene and Miocene strata of the United States, one of these also occurring in the French Eocene. The existing forms grow to a length of 6 feet, and are carnivorous, feeding upon smaller fishes. They are often known by the name of gar-pike, although, as mentioned on p. 400, that title is best restricted to a totally different group.

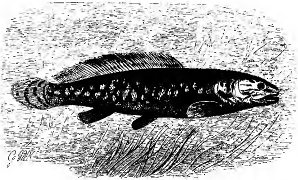


BONY-PIKE (⅙ NAT. SIZE).

Spear Beaks. The extinct Jurassic spear-beaks (*Aspidorhynchus*) constitute a second family (*Aspidorhynchidæ*), distinguished by the normal structure of the vertebræ, the homocercal tail, and the production of the upper jaw; the general form of the body and the arrangement of the fins being very similar to that obtaining in the bony-pike.

THE BOW-FIN AND ITS ALLIES,—Suborder **Protospondyli**.

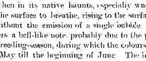
The so-called bow-fin (*Amia calva*) of the fresh waters of the United States is the sole existing representative of a second and larger subordinal group, differing from the last by the imperfect ossification of the skeleton, the notochord being either persistent throughout life, or if more or less completely replaced by vertebræ, those in front of the caudal region have their bodies composed of three distinct elements (pleurocentra and intercentrum), which remain separate and alternating even when fully developed. The lower jaw is complex, and composed of several pieces; in the pectoral arch the infraclavicular plate is absent, and the pectoral fin has more than three basal elements belonging to the true internal skeleton, while the tail is always abbreviated heterocercal.



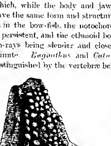
THE BOW-FIN (¼ nat. size).

Existing Family. Together with three extinct genera, the bow-fin constitutes a family (*Amiidæ*) characterised as follows. The lower jaw has its suspending arrangement directed backwards, and the cleft of the mouth is wide; the degree of ossification of the vertebræ is variable, although these often form complete discs; the body is elongate or fusiform; the margins of the jaws are armed with an outer series of large and conical teeth, internally to which are smaller ones; fulcra to the fins are either wanting or of minute size; and the dorsal fin is of variable, although usually of considerable length. Having the scales thin, somewhat rounded, and overlapping, the bow-fin represents a genus in which there are no fulcra, and the long dorsal fin occupies three-fourths the length of the body, while the anal fin is short, the caudal rounded, and the throat furnished with a single gular plate, followed by a number of branchiostegal rays. The single existing species of the genus, which attains a length of 2 feet, is confined to the fresh waters of the United States, where it is exceedingly abundant in some of the northern lakes, but remains of extinct species have been obtained, not only from the Eocene rocks of the same country, but likewise from the upper Eocene and Miocene strata of Europe. Carnivorous in its diet, preying both upon other fish and also upon aquatic crustaceans and insects, the bow-fin is capable of living for fully an hour out of water; and when in its native haunts, especially where the water is foul, comes frequently to the surface to breathe, rising to the surface, and taking in large mouthfuls of air without the emission of a single bubble. When near the surface, this fish often utters a bell-like note, probably due to the passage of air from the air-bladder. The breeding-season, during which the colours of the fish are more brilliant, lasts from May till the beginning of June. The bow-fins breed among floating islands of herbage fringing the great lakes. Here they lay thousands of minute eggs on the water-plants which form the base of a series of tunnels, composed partly of root-fibres, and partly of a moss-like growth. Of the nest thus formed, the male fish takes entire charge till the fry are hatched; the development of the eggs being unusually rapid. The embryos, while agreeing in many respects with those of the typical ganoids, are stated to approximate in other points to those of the higher bony fishes. *Megalurus*, from the upper Jurassic, is an allied extinct genus with a short dorsal fin and fulera; while the Jurassic *Eurycormus* and *Liodesmus* likewise belong to the same family.

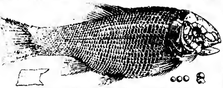
Extinct Families.


SKELETON OF AN EXTINCT AMIOID (*Caturus*).

Among several extinct families of which the members are mostly of Jurassic age we may notice the *Pachycormidæ* as represented typically by *Pachycormus*, in which, while the body and jaws have the same form and structure as in the bow-fish, the notochord is persistent, and the ethmoid bone fused with the vomer to form a long beak; the fin-rays being slender and closely set, the dorsal fin short, and fulera absent or minute. *Eugnathus* and *Caturus* are well-known members of a third family distinguished by the vertebræ being usually represented by incomplete rings, by the large fulera and the short dorsal fin; the caudal fin being forked. The Pycnodonts, ranging from the Lias to the Eocene, constitute another family group, in which the body is either deeply fusiform or rhomboidal; the notochord has no ossification around it; the cleft of the mouth is narrow; the teeth are small, nodular, and aggregated into a pavement, without vertical successors; the gill-cover is of a very simple type; branchiostegal rays and fulera are alike absent; and the dorsal fin is elongated. The family is typically represented by the genus *Pycnodus*; but we have figured as an example of the dentition the lower jaw of the allied *Mesodon*. Yet another family


RIGHT HALF OF THE LOWER JAW OF A PYCNODONT (*Mesodon*).—After Gaudry.

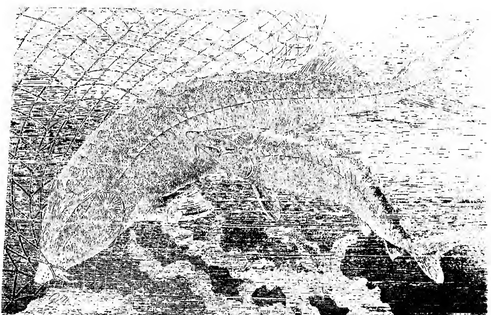
(*Dapediidae*) is represented by *Dapedius*, *Lepidotus*, and several other allied genera, in which the body is more or less deeply fusiform, the suspensory apparatus of the lower jaw either vertical or inclined forwards, the cleft of the mouth narrow, the teeth cylindrical or in the form of button-like knobs, the vertebræ not more than rings, and the dorsal fin not extending more than half the length of the body. In this family the teeth have vertical successors; and while some of the earlier genera date from the Trias, the scale-tooths (*Lepidotus*), of which an example is figured in the illustration, survived till the Chalk. Some of the species of this genus attained very large dimensions, and their remains are beautifully preserved in the Lithographic Limestone of Bavaria. In all these the scales are of the typical quadrangular ganoid type.



THE GIANT SCALE-TOOTH, WITH A DETACHED SCALE AND TEETH
(much reduced)

THE STURGEON-TRIBE.—Suborder Chondrostei

This important suborder brings us to the last group of the fan-finned fishes (Actinopterygii) which forms a division by itself differing in several important particulars from the one including the whole of the foregoing suborders; the more important characters of the first division having been given on p. 334. Whereas in that division the number of dermal rays in the dorsal and anal fins is equal to the supporting elements in the true internal skeleton, in the present division the dermal rays are more numerous than their supports. Then again, whereas in the former division the pelvic fins have their superior row of supporting ossicles, or *baseosts*, rudimental or wanting, in the present group these are well developed. The living representatives of the sturgeon tribe agree with the bow-fish and its allies in the want of any interlacing of the fibres of the optic nerves at their crossing, and likewise in the presence of a spiral valve to the intestine. In both the living and extinct types the tail is of either the diphycercal or heterocercal type. As a suborder, the sturgeon tribe may be characterised by the more or less completely persistent notochord, by the inferior and superior supporting ossicles (axonosts and baseosts) of the dorsal and anal fins forming a simple and regular series, and also by the presence of a pair of infraclavicular plates in the pectoral girdle. In all the known forms there is a single dorsal and anal fin, both of which are well separated from the caudal; while in the existing members the air-bladder is furnished with a duct. Although represented at the present solely by the sturgeons and their allies, the group was very abundant during the Secondary epoch; and whereas the sturgeons, together with certain extinct families, form what may be termed a degenerate specialised series characterised by the absence of ganoid scales, in a second and normal series the body was covered with such scales.



GIANT AND COMMON STURGEON.

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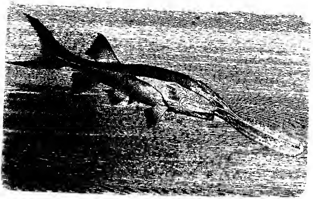
Toothed Sturgeons. The toothed sturgeons, of which there are two existing representatives, each forming a genus by itself, constitute the family *Polyodontidæ*. While agreeing with the other members of the series in having the cartilaginous skull invested with a series of superficial bony plates, these fishes are specially distinguished by possessing a median unpaired series of bones in this shield; by the absence of branchiostegal rays; the presence of minute teeth in the adult; the heterocercal tail, and by the skin being either naked or with some scales on the upper lobe of the tail. The first of the two existing genera is represented by the spoon-beaked sturgeon (*Polyodon folius*) of the Mississippi, which grows to a length of 6 feet, and is characterised by the production of the upper jaw into a very long spoon-like beak, with thin, flexible margins, equal to one-fourth the total length in the adult, but still longer in the young. The gill-cover ends in a long tapering flap: the upper lobe of the tail bears a numerous series of narrow fulcra; and the air-bladder is cellular. On the other hand, the slender beaked sturgeon (*Psephurus gladius*) from the Yang-tse-kiang and Hoangho rivers of China, differs in the more conical form of the beak, and in the large size and small number of the caudal fulcra. Growing to an enormous length—it is said as much as 20 feet—this fish agrees with the preceding in the very small size of its eyes, from which it may be inferred that both seek their prey without depending upon sight. Indeed, in the muddy waters of the rivers they inhabit, eyes can be of little use, and it has been suggested that these fish depend chiefly upon their beak, which is probably employed as an organ of touch. The flesh of both species is eaten. Among several fossil forms, we may mention the genus *Crossopholis*, of the North American Eocene, on account of the retention of a series of oblique rows of scales



SPOON-BEAKED STURGEON ($\frac{1}{15}$ nat. size).

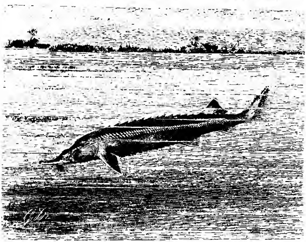
on the upper lobe of the tail, as we thus have evidence of the descent of the family from fully scaled fishes.

Toothless Sturgeons

From the preceding family the typical sturgeons (*Acipenseridæ*) may be distinguished by the absence of teeth in the adult, and the presence of five longitudinal rows of bony plates on the naked body, which is elongate and subcylindrical in form, as well as by the presence of four barbels in a transverse line on the under surface of the muzzle. The muzzle is somewhat produced, and either subspatulate or conical in form, with the small, transverse mouth on its lower surface. All the vertical fins are armed with a single series of fulcra on their front edges; the dorsal and anal are situated at a moderate distance from the caudal; and the large air-bladder is simple. Confined to the temperate regions of the Northern Hemisphere, sturgeons are either exclusively or partially fresh-water fish, some of them only ascending rivers for the purpose of spawning, after which they return to the sea. With the slender-beaked sturgeon, they include the largest fresh-water fishes of this region, several of the species commonly growing to 10 feet, while some are much larger. The females deposit enormous numbers of extremely minute eggs, the product of a single individual having been estimated at upwards of three millions during a season. This wonderful fecundity easily accounts for the enormous numbers in which sturgeon, in spite of constant persecution, still crowd the northern rivers during the spawning-season. In addition to the excellence of their flesh, sturgeon are valued for their roe, from which is manufactured caviare, and for their air-bladder, the inner coat of which forms the basis of isinglass. In a fossil state sturgeons are unknown before the upper part of the Eocene period. All the members of the genus are exceedingly voracious fishes, and the majority are mainly carnivorous. During the winter many or all of them crowd together, either in inlets of the sea, estuaries, or the deep pools of rivers, where they undergo a kind of hibernation; and it is stated that in some localities they bury their noses in the mud, with their bodies and tails standing vertically upwards like a series of posts. They increase very rapidly in size; and the eggs are hatched in five days. Although still abundant in the northern rivers, in those of Central Europe sturgeon have greatly decreased in numbers, and few really big fish are now taken. In the beginning of the year, when they are still torpid, sturgeon are captured by breaking the ice, and stirring up the mud at the bottom of their haunts with very long poles armed with barbed prongs. As the fish seek to escape, some are stabbed with the spears; and it is said that half a score of large fish may be thus taken by a single fisherman. In summer regular fishing-stations are established on the Russian rivers, where the approach of a shoal is heralded by a watchman. Upwards of fifteen thousand sturgeon have been taken in a day at one of these stations; and when the fishing is suspended for a short time, a river of nearly four hundred feet in width, and five-and-twenty in depth has been known to be completely blocked by a solid mass of fish.

True Sturgeons

The common sturgeon (*Acipenser sturio*), of which a small example is shown in the illustration facing p. 510, is the typical representative of the first genus, in which the rows of bony plates remain distinct from one another on the tail, spiracles are present on the head, the upper lobe of the tail is completely surrounded by the fin-rays, and the muzzle is either short or developed into a narrow beak of moderate length. There is some doubt as to the exact number of species of sturgeons, as these fish vary considerably according to their age, but it is probable that nearly twenty different kinds may be admitted. Among the better known forms one of the most esteemed is the sterlet (*A. ruthenus*), which although rarely exceeding a yard in length, yields better flavoured flesh and finer caviare than any of the others. It is characterised by its narrow, pointed snout, and by the great number of bony plates on the sides of the body; these varying from sixty to seventy. Common in the Black Sea and Caspian, as well as in their influent rivers, the sterlet is likewise found in the Siberian rivers, while it ascends the Danube as far as Vienna. In contrast to this species may be noticed the giant sturgeon, or hausen (*S. huso*), shown in our full-page illustration. Having from forty to forty-five lateral bony plates, this species may be readily distinguished by the absence of shields on the muzzle, which is rather short and pointed. It is found in the Black Sea, Caspian, Sea of Azov, and their tributaries, and occasionally enters the Mediterranean. At one time this sturgeon was to be met with in the Danube by thousands, among which specimens of upwards of 24 feet in length were by no means uncommon; but relentless slaughter has greatly reduced not only their numbers but likewise their size, although even now fish of from 1200 to 1500 lbs. weight are occasionally taken. These, however, are mere pigmies to certain Russian examples, one of which is stated to have weighed

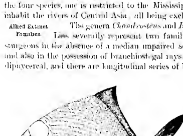


STERLET ($\frac{1}{10}$ nat. size).

2760 and a second 3200 lbs. Migratory in its habits, this sturgeon crowds into the Russian rivers as the ice is breaking up, when many individuals are more or less severely injured by being jammed against the floes. It appears that only full-grown fish ascend some rivers, as no small ones are found in the Danube; but in the Volga these sturgeon are stated to remain during the winter in a semi-torpid condition. Although extremely powerful, the hausen is an inactive and timid fish, fleeing even from the diminutive sterlet, and passing much of its time on the mud at the river-bottom, but rising occasionally to swim near the surface. In diet it is both carnivorous and herbivorous, feeding on vegetable substances, other fish, especially various kind of carp, and even water-fowl. Its isinglass is inferior to that of the common sturgeon. Rarely visiting the British coasts, where it is a "royal" fish, the latter species has only from twenty-six to thirty-one lateral plates, and from eleven to thirteen down the middle of the back, the muzzle being pointed, and about equal to one-half the length of the head. It is a widely distributed form, frequenting the coasts of both sides of the Atlantic, but absent from the Caspian, although found in the Black Sea. In Italy it ascends the rivers from March to May; and while in that country it does not commonly exceed 5 or 6 feet in length, specimens of upwards of 18 feet are on record.

Shovel-Beaked Sturgeons. The four species of the genus *Scaphirhynchus* (which must not be confused with the toothless sturgeons) differ from the preceding genus by the production of the muzzle into a spatulate beak, by the narrow and depressed hinder portion of the tail being completely covered by the bony plates, as well as in the absence of spiracles, and by the fin-rays not surrounding the extremity of the upper lobe of the tail, which terminates in a long filament. Of the four species, one is restricted to the Mississippi river-system, while the others inhabit the rivers of Central Asia, all being exclusively fluviatile in their habits.

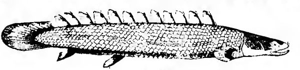
Allied Extinct Families. The genera *Chondrosteus* and *Belonorhynchus* from the European Lias severally represent two families differing from all the modern sturgeons in the absence of a median unpaired series of bones in the head-shield, and also in the possession of branchiostegal rays. In the latter family the tail is diphycercal, and there are longitudinal series of bony plates on the body; whereas in the former the tail is heterocercal, and the body is either naked or with a small series of scales on the upper lobe of the tail; both being furnished with teeth.


AN EXTINCT ACIPENSEROID FISH (*Platysomus*), from the Magnesian Limestone.

Scaled Types. The scaled types of this sub-order are so utterly unlike the sturgeons in external appearance that it is only by a study of their internal structure that their true affinities have been determined. They are all extinct, and mainly characteristic of the Secondary period, their remains being especially common in the British Lias. In both of the two principal families the tail is of the heterocercal type. In one family, as typified by the genus *Palæoniscus*, the body is elongated fusiform, and the teeth are slender and conical or straight. On the other hand, *Platysomus* represents a second family (*Platysomatidæ*), in which the body is rhomboidal, and the teeth—in the upper jaw mainly confined to the pterygoid bones—obtuse. In both groups the scales are of the ganoid type.

THE FRINGE-FINNED GANOIDS.—Order CROSSOPTERYGII

The whole of the members of the subclass under consideration described in the foregoing pages constitute one great order (Actinopterygii), characterised, as mentioned on p. 334, by the fan-like structure of the paired fins and frequently also of the caudal fin; the scales being generally of the cycloid or ctenoid type. These fishes form, indeed, the dominant group at the present day; whereas the group now to be considered is represented only by two existing species—referable to as many genera, and is mainly characteristic of the earlier epochs of the earth's history, being abundant even in the Devonian and Carboniferous epochs, since which time it has been steadily decreasing in numbers. These fringe-finned ganoids, as they may be called, have the paired fins lobate, with an internal longitudinal axis belonging to the true skeleton more or less fringed with dermal rays, the caudal fin being either of the diphycercal or heterocercal type. A pair of large jugular plates, bounded in some instances by a series of smaller lateral ones, and an anterior unpaired element, are developed in the branchiostegal membrane to fill up the space between the two branches of the lower jaw, and thus representing the branchiostegal rays of the first order. In all the scales are coated with ganoine, although they may be thin, overlapping and rounded or thick and quadrangular. The existing forms have the optic nerves simply crossing one another, a spiral valve in the intestine, and a duct to the air-bladder; the presence of the latter being also shown in certain extinct types. Next to the sharks and rays, this group is one of the oldest, being well represented in the Devonian.

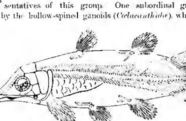


THE BICHIR.

Existing Species. The sole existing survivors of this great group of fishes are the bichir (*Polypterus bichir*) of the Nile, and other rivers of Tropical Africa, and the reed-fish (*Calamoichthys calabaricus*) from Old Calabar; these constituting the family *Polypteridæ*, which has no fossil representatives, and probably forms a subordinal group by itself. In this family the notochord is more or less constricted and replaced by ossified vertebræ; the basals or superior supporting elements, are rudimentary, or wanting, in the median fins; whereas the axonosts, or inferior supports, form a regular series equal in number to the dermal fin-rays with which they articulate. The scales are ganoid, and the fins without fulcra. The dorsal fin is divided into a number of finlets, each formed by a spine in front and a series of rays behind; the anal fin being situated close to the diphycercal caudal, and the vent near the end of the tail, while the whole caudal region is very short. In the bichir the body is moderately elongated; the teeth are rasp-like, and arranged in broad bands in the jaws and on the vomers and palatines, the jaws also bearing an outer series of larger pointed teeth; and the pelvic fins are well developed, but do not show the obtusely lobate structure characterising the front pair. The large air-bladder is double. The bichir is found in the Upper Nile and the rivers on the west coast of Tropical Africa, examples being occasionally carried down into the Lower Nile. The number of finlets varies from eight to eighteen, and in size this fish grows to as much as 4 feet. Nothing is known of its habits. The reed-fish is a smaller form, characterised by the great elongation of the body, and the absence of pelvic fins.

Extinct Families

Very little can be said here as to the numerous extinct representatives of this group. One subordinal group (Actinistia) is represented by the hollow-spined ganoids (*Cœlacanthidæ*), which range from the



SKELETON OF A HOLLOW-SPINED FRINGE-FINNED GANOID, *Undina*.
(From A. S. Woodward, *Cat. Foss. Fish, Brit. Mus.*)

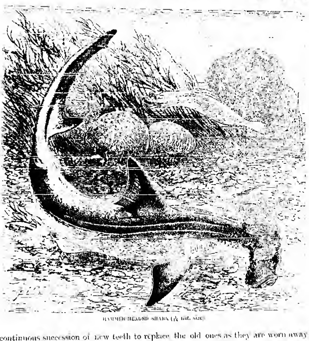
Carboniferous to the Jurassic, and are best known by the genera *Cœlacanthus* and *Undina*. In these fishes (as shown in the accompanying figure) the notochord persists; the axonosts of the anal and two dorsal fins are fused into a single piece; in the caudal fin the dermal fin-rays are each supported by a series of axonosts equal in number to the upper and lower spines of the vertebræ, and each pelvic has a single axonost, which is not united with that of the opposite side. In these fishes the body is deeply and irregularly fusiform, with the scales overlapping, rounded, and more or less coated with ganoine. There is a gill-cover and a single pair of jugular plates; the paired fins are obtusely lobate; the tail is diphycercal, frequently with a small supplemental fin at the extremity: and the air-bladder is ossified. A third suborder (Rhipidistia) includes most of the other forms, especially those from the Devonian formation, and while agreeing with the preceding group in having a more or less completely persistent notochord, and the axonosts of the anal and two dorsal fins each fused into a single piece, differs in that in the caudal and other median fins the baseosts are fewer in number than the dermal fin-rays, by which they are overlapped. The suborder is represented by three well-defined families. In the first, which is typified by the genus *Holoptychius*, the lobes of the pectoral fins are long and acute, while the teeth have complex infoldings of the outer layer, somewhat after the manner of those of the primeval salamanders, and the scales are thin and cycloidal. The second family, of which *Rhizodus* is the typical genus, differs by the lobes of the pectoral fins being shorter and blunter, and also by the less complicated infoldings of the teeth. To this family belongs *Gyroptychius*, from the Devonian or Old Red Sandstone of Scotland. While agreeing with the last in the obtusely lobate pectoral fins, the third family, as represented typically by *Osteolepis* of the Old Red Sandstone, is characterised by the walls of the teeth being slightly infolded only at their bases, and by the scales being of the true quadrangular, ganoid type. Remains of these fishes occur in extraordinary abundance in the Old Red Sandstone of Scotland; and as this deposit is of fresh-water origin, it is evident that they were either fluviatile or lacustrine forms. The reason why these and so many other ancient creatures were enveloped in coats of-mail has not yet been discovered.

CHAPTER IV.

SHARKS AND RAYS,—Subclass ELASMOBRANCHII.

THE last subclass of the fishes is represented by the existing sharks and rays, together with a number of more or less closely allied extinct forms, some of the latter being the most primitive members of the order yet known. Indeed, taking these primitive types into consideration, and remembering that sharks and their allies are the oldest fishes with which we are acquainted—dating from the lower Ludlow beds of the Silurian epoch—it seems probable that the present subclass may have been the stock whence all other fishes were derived. Agreeing with the bony fishes and ganoids in having the suspending apparatus of the lower jaw movably articulated to the skull (generally with the intervention of a distinct hyomandibular element) the sharks and rays have the skeleton entirely cartilaginous throughout life; membrane-bones—except in one extinct group—being entirely wanting. The gills open by separate external clefts, and have no cover. When bony elements are developed in the skin, these agree in structure with teeth, and have nothing to do with true bone. In all the living members of the subclass the optic nerves cross one another without giving off any mutually interlacing fibres, the arterial bulb of the heart is furnished with three valves, the intestine has a spiral valve, the eggs are large and detached, and an air-bladder is wanting.

The whole of the existing representatives of the subclass form an order (Selachii) characterised by the cartilaginous internal skeleton being, as a general rule, only superficially calcified; while, except in some of the earlier extinct types, the notochord is constricted at the centre of each vertebra. The superior and inferior arches of the vertebræ are short and stout, and intercalary cartilages are very generally developed. The pectoral fin has not a segmented longitudinal central axis, its cartilaginous rays forming a fan-shaped structure radiating from an abbreviated base, into the anatomical details of which it will be unnecessary to enter here; and the axis of each pelvic fin is developed in the males into a "clasper," connected with the reproductive function. With regard to the structure of the skull, it may be mentioned that the hyomandibular usually intervenes between the palatopterygoid bar (forming the functional upper jaw, and carrying the teeth) and the cranium proper; but in the genus *Notidanus* the hyomandibular takes no share in the support of the jaws, the palatopterygoid bar articulating directly with the cranium by means of a facet behind the socket of the eye; this structure being probably the original one. We have already said that the tooth-bearing palatopterygoid bar serves the function of an upper jaw, by which name it may be conveniently referred to; and similarly the functional lower jaw is in reality the element known as Meckel's cartilage. The gills are attached to the skin by their margins, and usually communicate with the exterior by means of five vertical slits on the sides of the neck, although occasionally the number of these clefts is increased to six or seven. Very generally the mouth is situated on the inferior aspect of the head; and the teeth carried on the functional jaws may be either sharply-pointed and separate, or blunt and articulated together, so as to form a more or less pavement-like structure. In the former case there is a continuous succession of new teeth to replace the old ones as they are worn away and shed. As a rule, the tail-fin is heterocercal, with the upper lobe greatly elongated; the pelvic fins are always abdominal in position; and the dorsal fins of many extinct and a few living types bear large spines on their front edge, which, unlike those of the bony fishes, are simply imbedded in the flesh without articulating with the internal skeleton, and are consequently immovable. Spiracles are frequently developed on the upper surface of the head; and the intercalary cartilages already alluded to are ovoid or diamond-shaped structures occurring



HAMMER-HEADED SHARK ($\frac{1}{16}$ nat. size).

between the superior arches of the vertebræ. The eggs are generally invested in horny rhomboidal capsules, furnished at the four corners with long tendril-like filaments by which they attach themselves to the stems of seaweeds and other bodies, as shown in the figure of the lesser spotted dog-fish given on p. 529. In some species, however, the eggs are hatched within the body of the female; and in all cases the embryos are furnished with external gills, which are shed before birth. All the members of the order subsist on animal substances; but whereas the typical sharks are highly predaceous creatures, seizing and devouring everything they come across, some of the largest species are armed only with small teeth, and feed on molluscs and other invertebrates. The rays, too, are largely shell-fish eaters, and most of them differ from the sharks in living on or near the bottom instead of swimming about actively at or just below the surface. All the species are typically marine, but many ascend tidal rivers, and in the Viti Levu Lake in Fiji, as well as in the Nicaragua Lake in South America, there are sharks dwelling permanently in fresh water. The species inhabiting the former lake, which is cut off from the sea by a cataract, is *Carcharias gangeticus*, common alike in the Ganges and in the Tigris, and ascending in the latter river to a distance of three hundred and fifty miles from the sea in a straight line. Then, again, a species of saw-fish is found in a fresh-water lake in the Philippines. It has been commonly stated that sharks have the power of scenting their prey from a distance, since they rapidly congregate whenever animal refuse or other decomposing matter is cast overboard from a ship; but it may be suggested that such assemblages, as in the case of vultures, are rather due to one shark following the movements of another, and thus being attracted to the central point. The order was formerly divided into two subordinal groups, based upon the conformation of the body; the one group including all the sharks and dog-fishes, and the other the rays and their immediate allies. It has been found, however, that although this difference in bodily form is of considerable importance in classification, yet that it does not constitute the essential line of distinction, which is based upon a difference in the internal structure of the bodies of the vertebræ. Taking this character as a basis, the members of the order may be arranged in two subordinal groups, the first of which comprises the true sharks and dog-fishes, while the second includes the spiny dog-fishes, saw-fishes, eagle-rays, and rays.

THE BLUE SHARK AND ITS ALLIES.—Family *CARCHARIIDÆ*.

The well-known blue shark (*Carcharias glaucus*), of which examples are depicted in our coloured Plate, may be taken as the typical representative of the leading family of the first suborder. Before, however, indicating the characters of the family, we must refer to those of the suborder, for which the name of Asterospondyli has been suggested. The essential feature of this group is to be found in the circumstance that when the bodies of the vertebræ are fully calcified, the radiating plates in the interior predominate over the circular ones, so that a transverse section presents a star-like arrangement. All these fishes have an anal fin, and the form of the body elongated and subcylindrical, while the tail is powerful and well adapted for swimming. In no case are the pectoral fins

expanded; and the spiracle is always small and may be wanting. The front teeth, and very frequently also those on the sides of the jaws, are formed on the type of a laterally compressed cone with cutting edges, at the base of which two or more smaller cones may be developed; but in one existing and many extinct genera the hinder teeth have blunt crowns adapted for crushing. The two branches of the jaws do not run parallel to each other, in consequence of which the teeth form oblique rows, whereas in the rays they are set in straight longitudinal rows. From the other sharks the members of the present family may be distinguished by the absence of spines in both the dorsal fins, of which the first is situated above the interval between the pectoral and pelvic pairs; by the presence of a nictitating membrane to the eye; and by the teeth when fully formed, being hollow, and usually pointed. The bony elements in the skin take the form of minute granules, thus constituting the well-known "shagreen," as the dried skin is termed.

Typical Genus. In all the members of the typical genus (*Carcharias*) the muzzle is produced forwards, and the inferiorly-placed mouth is crescentic and armed with large, flat, triangular, single-coned teeth, of which the upper ones differ considerably in form from those of the lower jaw. Spiracles are absent, and there is a pit at the root of the caudal fin, which has a distinct lower lobe. At the present day these sharks are represented by between thirty and forty species, of which the blue shark is one of the commonest and most widely distributed; while in a fossil state the genus is known from the Tertiary formations. The blue shark frequently attains a length of from 12 to 15 feet, but some of the other species are stated to grow to as much as 25 feet. In common with the other larger members of the suborder, all these sharks are more abundant in tropical than in temperate seas; but the blue shark is by no means an uncommon visitor to British waters, more especially on the southern and western coasts of Ireland. Mr. J. T. Carrington writes that they more usually wander to the British coasts "in warm weather, especially in autumn, but they have been seen in June, and even in the month of March. They are nocturnal in their more active habits, taking rest and sleep in the daytime, often on the surface of the water, with a portion of the dorsal fin and extremity of the tail exposed above in the air. So gentle are they in their movements that, unlike many other monsters of the deep, they do not disturb the luminous creatures, which at the same time will be lighting every wavelet with their phosphorescence. Blue sharks are not very particular as to what fish they take as food, though those which are gregarious in their habits, like mackerel, pilchards, and herring, are most commonly hunted by them. It is on record that big fish, such as congers and the larger dog-fish, were found in a dead specimen from Cornwall. Occasionally they become entangled in the drift-nets set by the pilchard-fishers, but these sharks will also take a bait. Great care is necessary in landing a hooked specimen, in case it gives a blow with its tail, which may result in serious consequences, such as broken limbs or ribs." It is a somewhat remarkable fact that in places like Aden, where sharks of various kinds abound, the natives will swim and dive fearlessly in the open sea, where a European would be almost instantly devoured by these monsters. The blue shark has the whole of the upper parts slaty blue, and the under surface white.

Tope

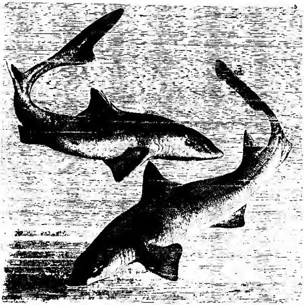
Our next representative of the family is the small shark commonly known as the tope (*Galeus canis*), which belongs to a genus including only two species and characterised as follows. The muzzle is short and the mouth crescent-shaped; very small spiracles are present; there is no pit at the root of the caudal fin, which has only a single notch; and the teeth, which are similar in the two jaws, have serrated edges, and a notch on the hinder border. The common tope, which is usually about 6 feet in length, although it may grow to 7 feet, is a very widely spread species, ranging over all temperate and tropical seas, and visiting the shores of such widely separated localities as California, the British Islands, and Australia. In colour it is dark grey above, and dirty white beneath. The second living species inhabits the Japanese seas; and teeth from the Tertiary formations of Europe have been referred to the genus. In habits the tope is a bottom-haunting species—especially during the winter months—and devours other fish, crustaceans, and star-fishes. It is not unfrequently taken by the line, and is thus a great source of annoyance to fishermen, especially on the Norfolk coast, where considerable numbers are sometimes hooked. The young are produced alive, and it is stated that there have been instances of as many as fifty individuals in a single brood.

Hammerheads

Having teeth very similar to the true sharks, the five species known as hammerheads, or hammer-headed sharks, one of which (*Sphyrna malleus*) is represented in the illustration on p. 521, form a genus unique among fishes in the extraordinary conformation of the head. Instead of retaining the usual more or less pointed form, the front part of the head of these sharks is broad, flattened, and expanded on each side into a process, on the flat terminal surface of which is situated the eye. This, of course, is quite sufficient to distinguish the genus; but it may be added that the caudal fin has a single notch and a pit at its root, there are no spiracles, the nostrils are situated on the front edge of the head, and the mouth is crescent-shaped. The teeth differ from those of the true sharks in being similar in both jaws; their margins being either smooth or serrated. Hammerheads range over all the warmer seas, the common species being sometimes taken on the British coast; and an extinct form occurs in strata of Miocene age. Growing to a length of some 14 or 15 feet, the common hammerhead is one of the most formidable and voracious of its tribe, and is much feared in the Indian seas.

Hounds

By this somewhat inappropriate title are designated two small British sharks, one of which (*Mustelus lævis*) is shown in the lower figure of the accompanying illustration. Externally these sharks are not unlike the tope, but the snout is less pointed. As a genus they are characterised by the rather short muzzle; the crescent-shaped mouth; the presence of minute spiracles; the absence of a pit at the base of the caudal fin, which has scarcely any lower lobe; and the slight difference in the size of the two dorsal fins. The teeth, moreover, are small and numerous, being either blunt or with indistinct cusps, and forming a kind of pavement-like structure; those in the upper jaw being similar to those in the lower. The smooth hound, which is the species here figured, is generally about 4 feet in length, although it may reach to 6 feet. The sides of the back are marked by a series of whitish spots, more distinct in the young than in the adult. Feeding on molluscs and crustaceans, this species (which ranges over most warm seas) produces about a dozen young at a birth, these being attached by a placental structure to the walls of the uterus of the parent. Curiously enough such connection is, however, totally wanting in the young of the other British species (*M. vulgaris*). In habits the hounds are bottom-haunting species, as indeed might be inferred from the nature of their food. On



SPINY DOG-FISH AND SMOOTH HOUND (¹ nat. size).

the English coast the smooth hound generally makes its appearance during the summer in pursuit of the shoals of pilchard and herring. Several other genera of this family must be passed over without notice.

THE PORBEAGLE GROUP,—Family *LAMNIDÆ*.

Agreeing with the typical sharks in the position of the two spineless dorsal fins, the members of the present family may be distinguished by the absence of a nictitating membrane to the eye, and also by the solid structure of the fully formed teeth which are pointed, and in most of the genera relatively large. In addition to these features, it may be noted that the gill-openings are generally wide, and the spiracles either minute or wanting. This family dates from the period of the Chalk, where there occur remains of species some of which are referable to genera still existing, such as the porbeagles, while others indicate extinct generic type. The fox sharks and the gigantic *Carcharodon* are, however, unknown before the Tertiary period.

Porbeagles

The shark (*Lamna cornubica*) commonly known to the British fishermen as the porbeagle—a word supposed to be derived from its porpoise-like appearance and active predatory habits—is the type of a genus containing three existing species, and characterised by the small size of the second dorsal and anal fin, and the presence of a pit at the root of the caudal fin—of which the lower lobe is much developed—and also of a keel along the sides of the tail. The teeth are narrow and slender, with one or two pairs of small accessory cones at their bases, the edges of the main cone being smooth. The common porbeagle wanders all over the North Atlantic, and has also been taken in Japan; it does not commonly exceed 10 feet in length, and its colour is dull grey above and whitish beneath. Its food chiefly consists of fishes, which are apparently swallowed whole; the lancet-like teeth of this shark being apparently more adapted for seizing and holding than for tearing prey. The porbeagle is stated to be a viviparous species.

Rondeleti's Shark.

The most formidable of all the existing members of the group is the gigantic Rondeleti's shark (*Carcharodon rondeletii*) distinguished from the porbeagles by the great size of the broadly triangular teeth, which have strongly serrated edges, and may possess basal cusps. The existing species, which is a purely pelagic creature ranging over all the warmer seas, is known to attain a length of 40 feet, one of the teeth of a specimen of 36 feet in length measuring 2 inches along the edge of the crown, and $1\frac{3}{4}$ inches across the base. Similar teeth are found in the Crag deposits of Suffolk, and are referred to the existing species; but from these same beds, and also from the bottom of the Pacific between Polynesia and Australia, there are obtained other teeth of much larger dimensions, some of them measuring upwards of 5 inches along the edge and 4 inches in basal depth. These teeth evidently indicate sharks beside which the existing form is a comparative dwarf; and it is not a little remarkable that the specimens dredged from the bed of the Pacific indicate that these giants must in all probability have survived to a comparatively recent date. Observations are still required as to the mode of life and breeding habits of Rondeleti's shark. Two other species of large sharks constitute the genus *Odontaspis*. With teeth almost indistinguishable from those of the porbeagles, these species differ by the second dorsal and anal fins being nearly as large as the first dorsal, and the absence of a pit at the root of the caudal fin and of a keel on the sides of the tail.

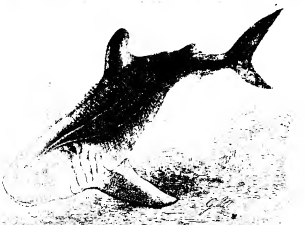
Fox Shark

Another species not uncommonly met with in British waters is the fox-shark or thresher (*Alopecias vulpes*), the sole representative of its genus, and easily recognised by the inordinate length of the upper lobe of its tail fin, from which it derives its name. Growing to a length of 15 feet or which more than half is taken up by the tail, this shark has the second dorsal and anal fins very small; the caudal fin extremely elongated, and without a pit at its root; no keel on the sides of the tail; and the teeth, which are similar in both jaws, of small size, compressed and triangular, with smooth edges. Like most sharks, the thresher has a wide range, being abundant throughout the Atlantic and Mediterranean, and also found off the coasts of New Zealand and California. The comparatively small size of its teeth indicates that it is not adapted for killing large prey; and, as a matter of fact, this shark chiefly feeds upon the various species of the herring tribe and mackerel, among which it inflicts terrible destruction. It derives its name of thresher from its habit of beating the water with its long tail in order to drive the members of the shoals on which it preys into a compact mass, when they can be the more readily seized; and its voracity may be inferred from the fact of no less than nineteen mackerel and two herrings having been taken from the stomach of a single individual. It is commonly reported by sailors that threshers, in company with killers and sword-fish, make attacks on whales by leaping high in the air and belabouring the unfortunate cetaceans with powerful blows of their tails as they descend; but these statements have been generally discredited by naturalists, apparently on the ground that the teeth of these sharks are not adapted for rending the flesh of large animals. It is, however, somewhat difficult on such grounds to refuse to believe the circumstantial accounts we possess, and it may be that the threshers join in the fray in order to feed on the smaller fragments left by their more powerfully armed coadjutors.

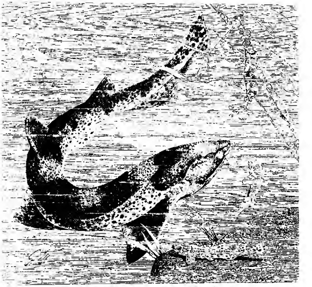
Basking Shark. The largest of the North Atlantic members of the suborder is the basking-shark (*Cetorhinus maximus*), which now alone represents a genus with the second dorsal and anal fins very small, a pit at the root of the caudal fin, a keel on each side of the tail, the gill-clefts very large and wide, and the teeth very small, numerous, and conical, without basal cusps, and seldom serrated at the edges. This shark, which grows to a length of over 30 feet, is regularly hunted on the west coast of Iceland for the sake of the oil from its liver, of which a single fish may yield considerably more than a ton. It derives its name from its habit of lying motionless during calm, warm weather on the surface of the water, with the tall first dorsal fin and a considerable portion of its back exposed; several individuals often consorting together. The gill-arches are provided with very long rakers bearing granular tooth-like structures; and in the young the muzzle is relatively longer and more pointed than in the adult. Unless attacked, when it can inflict blows with its tail capable of staving in the sides of a boat, this shark is perfectly harmless, its food consisting entirely of small fishes which swim in shoals and various invertebrates. Remains of an extinct species occur in the Pliocene deposits of Belgium, while others from older Tertiary beds have been tentatively assigned to the genus.

INDO-PACIFIC BASKING-SHARK.—Family *RHINODONTIDÆ*.

Although resembling the true basking-shark in the large size of its gill-clefts and the structure of its gill-rakers, the gigantic species (*Rhinodon typicus*) figured in the illustration on p. 528 differs in having the mouth and nostrils situated near the extremity of the muzzle, as well as in the backward position of the small first dorsal fin, which does not reach to the level of the highest point of the back, instead of standing immediately above it. Moreover, instead of being subcylindrical, the whole body of this shark is markedly depressed, and the huge mouth forms a nearly oblong aperture, and is armed with bands of very small and numerous teeth. The sides of the tail bear a well-defined keel, and the lower lobe of the caudal fin is well developed. In its varied coloration this fish differs markedly from the majority of sharks, being ornamented with buff spots and stripes upon a dark ground. Although probably widely distributed within the tropics, this monster has hitherto been met with but locally. For many years the sole evidence of its existence rested upon a specimen 15 feet long, brought ashore in Table Bay in April 1828, which fell into the hands of the late Sir Andrew Smith, who described and figured it. This specimen was preserved by a French taxidermist, who sold it to the Paris Museum, where it still remains. Forty years later, in 1868, Dr. Percival Wright, whilst staying at the Seychelles, met with this shark, and obtained the first authentic information about it. It does not seem to be rare in that archipelago, but is very seldom obtained on account of its large size and the difficulties attending its capture. Dr. Wright saw specimens which exceeded 50 feet in length, and one that was actually measured proved to be more than 45 feet long. Nothing more was heard of the species until January 1878, in



INDO-PACIFIC BASKING-SHARK ([illegible] nat. size) which year the capture of another specimen was reported from the Peruvian coast near Callao; finally, in the "nineties" it was discovered on the west coast of Ceylon, where two or three specimens were obtained. One of these was presented to the British Museum; and having been mounted is now exhibited in the Fish Gallery, where it forms one of the most striking objects, although only a young example, measuring 17 feet from the end of the snout to the extremity of the tail. It has been stated that this fish feeds on seaweeds, but it is more probable that its food is similar to that of the basking-shark.



LESSER SPOTTED DOG-FISH AND ITS EGGS (¼ nat. size).

The Dog-Fishes and their Allies.—Family *Scylliidæ*.

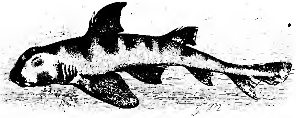
Agreeing with the preceding families in the absence of spines to the dorsal fin, the dog-fishes and their allies may be distinguished from the sharks hitherto noticed, in which the mouth is inferior in position, by the more backward situation of the first dorsal, which is placed above or behind the line of the pelvic fins. They have no nictitating membrane to the eye; and the teeth are small, with several series generally in use at the same time. In all there are distinct spiracles.

True Dog-Fishes Represented in British waters by the larger (*Scyllium canicula*), and lesser spotted dog-fish (*S. catulus*), this genus is characterised by the first dorsal fin being above or behind the line of the pelvic pair; by the origin of the anal being in advance of the line of that of the second dorsal; the absence of serration of the upper edge of the caudal fin; and the small and delicate teeth, which are arranged in numerous series, and generally have a long central cusp, flanked by one or two small ones on each side. About half a score of species have been described, ranging over the coast-regions of most temperate and tropical species, and all of comparatively small size; the majority having prettily spotted skins. Their food consists mainly of crustaceans and molluscs; and their flesh is eaten not unfrequently by fishermen, while in the Orkneys, where the British species are more abundant than elsewhere, it is regularly dried for winter consumption. The shagreen of their skins is also employed in wood polishing. These sharks lay eggs of the form shown in our illustration. Fossil dog-fishes date from the period of the Chalk; and they are represented in the Kimeridge Clay by the extinct *Palæoscyllium*, in which the origin of the second dorsal fin is placed in advance of that of the small anal.

Other Genera Among several allied genera we may especially notice the zebra-shark (*Stegostoma tigrinum*) of the Indian Ocean, attaining a length of from 10 to 15 feet, and noticeable for its handsome coloration, which consists of a brownish yellow ground-colour, marked with black or brown transverse bars or round spots. In this fish the first dorsal fin is above the line of the pelvic pair, while the second is in advance of the line of the anal, which is approximated to the caudal; the latter being greatly elongated and equal to half the total length. Young specimens of this shark are generally met with near the coast, but the adults are more or less pelagic. Dog-fishes of smaller size from the Indian Ocean constitute the genus *Chiloscyllium*, in which the first dorsal fin is either above or behind the line of the pelvics, while the anal is far behind that of the second dorsal, and close to the caudal; the teeth being small and triangular, with or without lateral cusps. The existing species are very handsomely ornamented with dark bands and spots. In a fossil state the genus has been recorded from the Miocene Tertiary. Three bottom-haunting sharks from the Japanese and Australian seas have been described under the name of *Crossorhinus*, and are remarkable for the presence of leaf-like expansions of the skin on the sides of the head. As in the case of other fish similarly adorned, these structures are probably for the purpose of attracting prey; and in order that they may be well concealed these sharks have a coloration closely assimilating to that of a rock covered with seaweed or corallines.

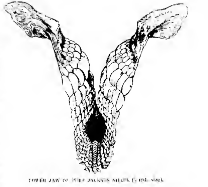
THE PAVEMENT-TOOTHED SHARKS.—Family *CESTRACIONTIDÆ*

The well-known Port Jackson shark (*Cestracion philippi*) and three allied species are the sole existing representatives of a family which was exceedingly abundant during the Secondary epoch. They differ from all the foregoing in the presence of a strong spine on the front edge of each of the two dorsal fins. The first dorsal fin is situated above the space between the pectoral and pelvic pairs; and the teeth, of which several series are in use at the same time, are more or less blunt and broad, more especially in the hinder part of the jaws, although those in each oblique row are never fused together into continuous plates. In



PORT JACKSON SHARK (⅙ nat. size).

the existing genus there is no nictitating membrane to the eye: the body is moderately elongated, with the second dorsal fin in advance of the line of the anal; and the mouth is almost or quite terminal. In the dentition, the front teeth are small, numerous, and sharp, while the hinder ones are broad and flattened, with a slight longitudinal ridge and a net-like ornamentation. The spines of the dorsal fins are smooth, covered on the sides with a thick layer of ganoin; the shagreen is fine; and the head is devoid of spines. In the existing species the egg-capsules assume a remarkable screw-like form, quite unlike that of any other member of the family. The living members of the genus, none of which exceed 5 feet in length, have been recorded from the seas of Japan, Amboyna, Australia, the Galapagos Islands, and California; while remains of extinct forms occur in the Cretaceous and Upper Jurassic strata of Europe. Very little appears to be known as to their habits; but their food is stated to consist principally of molluscs, the hard shells of which are crushed by the pavement-like hinder teeth.

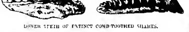


LOWER JAW OF PORT JACKSON SHARK (½ nat. size).

Extinct Types Of the numerous fossil genera of the family only a very brief mention can be made. One of the earliest is the Carboniferous *Orodus*, with teeth very like those of the later *Hybodus*, ranging from the Trias to the lower Cretaceous. In the last-named genus the notochord is persistent, the bluntly conical or cusped teeth have a central and two or more lateral cusps, the fin-spines are ridged, and there are two hook-like spines below each eye. *Acrodus*, with a nearly similar range, has, on the other hand, blunt teeth; while the Jurassic *Asteracanthus* differs from *Hybodus* by its rhomboidal, roughened, and flattened teeth and the star-like ornamentation of the spines of the dorsal fins. In *Synechodus* of the Chalk all the teeth are cusped; the anterior ones having a tall central cusp, flanked with from three to five small lateral pairs. An allied extinct family (*Cochliodontidæ*), confined to the Carboniferous rocks, differs by the component teeth of at least one of the oblique rows being fused into a continuous curved plate, which may be either smooth or ridged. Many of the extinct representatives of these families exceeded the Port Jackson shark in size.

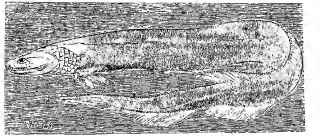
THE COMB-TOOTHED SHARKS.—Family *NOTIDANIDÆ*.

A very remarkable family is now represented by the four species of comb-toothed sharks (*Notidanus*) and the frill-gilled shark (*Chlamydoselache anguineus*), the latter of which is shown in the illustration. Whereas in all other sharks the gill-clefts are four in number, in the present family they are increased to five or six; while there is a further peculiarity in regard to the structure of the skull. It has been already stated (p. 520) that in the more typical sharks the functional lower jaw is articulated to the cranium by the intervention of the hyomandibular element; but in the Port Jackson shark this element becomes reduced in size, and the palatopterygoid bar (the functional upper jaw) has a facet by which it articulates directly with the cranium. In the present family, on the other hand, the hyomandibular takes no share in the suspension of the jaws, which are articulated to the cranium solely by means of the facet on the palatopterygoid bar, the latter joining a corresponding facet on the cranium behind the socket for the eye. In addition to their more numerous gill-slits, the comb-toothed sharks are distinguished externally from all those hitherto considered by having only a single dorsal fin, which is situated far back on the body and has no spine. The eye is devoid of a nictitating membrane; the spiracles are small; and the teeth, of which several series are in use at the same time, have sharply-pointed cusps.


LOWER TEETH OF EXTINCT COMB-TOOTHED SHARKS.

Typical Genus In the typical genus the body is moderately elongated, the mouth inferior in position, and the gill-openings, which may be either six or seven in number, are devoid of flaps. The principal teeth consist of a series of cusps placed upon a long base, all inclining in one direction, and decreasing in size from the front to the back; the number of these cusps being greater in the teeth of the lower than in those of the upper jaw. With the occasional exception of some portions of the tail, the notochord persists throughout life. At the present day the range of the existing members of the genus includes most temperate and tropical seas, some of the species reaching as much as 15 feet in length. Whereas in the grey comb-toothed shark (*Notidanus griseus*), of the Atlantic and Mediterranean, the number of gill-clefts is six, in each of the other three species it is seven. Fossil species occur from the Pliocene to the middle Jurassic; many of these, like the one of which two teeth are shown in the illustration, being of much larger dimensions than any of the existing forms. As to the habits of these sharks, there appears to be practically no information.

Frill-Gilled Shark. From the typical genus of the family the Japanese frill-gilled shark differs by the greatly elongated and slender form of the body; and by each of the six gill-clefts being protected by a frill-like flap of skin. The teeth are also of a somewhat simpler structure, being similar in both jaws, and each consisting of three slender, curved, and subconical cusps, separated by a pair of rudimentary ones; while there is an unpaired median series at the extremity of the lower jaw only, instead of in both the upper and the lower. Although mainly persistent, the notochord is in part replaced by ill-developed vertebræ of the type characteristic of the suborder. Fossil teeth from the European Miocene have been assigned to this genus.



FRILL-GILLED SHARK.

THE SPINY DOG-FISHES AND THEIR ALLIES,—Family *SPINACIDÆ*

Although the members of the present family approximate in their external conformation more to the typical sharks than to the rays, yet in the structure of their vertebræ they agree with the latter. Accordingly, both the spiny dog-fishes, rays, saw-fishes, and their kindred are regarded as forming a suborder (Tectospondyli) distinguished from the one including the preceding families by the following characters. In the bodies of the vertebræ, when fully developed, the concentric calcified plates are more numerous than those radiating from the centre;

and the anal fin is invariably wanting. In the more specialised forms the body is greatly developed, and the pectoral fins attain an enormous development, while the spiracles are of large size, and always retained. The present family includes the most generalised members of the group, in which the body is cylindrical or triangular, and but very slightly depressed, the mouth being gently arched, and the muzzle blunt. The pectoral fins have no forward prolongation, and are not notched at their point of origin, and the small and lateral gill-clefts may be either in the line of the pectorals, or half below. The large spiracles are placed behind the eyes; there is no nictitating membrane to the eye; and the two dorsal fins may or may not be provided with spines.

Spiny Dog-Fish. The common spiny, or picked, dog-fish (*Acanthias vulgaris*), shown in the upper figure of the illustration on p. 525, is the most familiar representative of a very small genus characterised by the presence of spines to the dorsal fins, and by the peculiar form of the teeth, which are similar in the two jaws, and small, triangular, and compressed, with the points much turned aside, and the cutting-edge formed by the inner margin. The common species measures from 3 to 4 feet in length, and is slaty blue above, and yellowish white beneath. It is very abundant on the British coasts, sometimes making its appearance in such incredible numbers that upwards of twenty thousand were once captured in a single haul on the Cornish coast. In common with an allied species (*A. blainvillei*), this dog-fish presents the peculiarity of inhabiting the two temperate zones but being unknown in the intervening tropical seas. The eggs are hatched within the body of the female, and a considerable number of young are produced at a birth. Somewhat dangerous wounds result from the spines.

Other Genera. Among other types, we may notice the genus *Centrophorus*, represented by eight European species, and a ninth from the Moluccas, all of which differ from the last by the upper teeth being erect and spear-like, with a single cusp, the dorsal spines being often very small. Apparently not exceeding 5 feet in length, these sharks are noteworthy on account of the depth at which they live; one of the species being caught with lines at a depth of from three to four hundred fathoms off the coast of Portugal. When hauled up, these fish are quite dead, owing to the diminished pressure. A fossil species occurs in the Chalk of Syria. In the typical genus *Spinax* the teeth in the two jaws are likewise dissimilar, but those of the lower one are broader than in the last, although with the points similarly turned aside. The genus is now represented by three small species from the Atlantic and the extremity of South America; but has been recorded from the Miocene Tertiary. The Greenland shark (*Laemargus borealis*) of the Arctic seas, which occasionally strays as far south as Britain, represents another genus characterised by the small size of all the fins and the want of spines to the dorsals, the first of which is situated considerably in advance of the pelvic pair; the skin being uniformly covered with small tubercles. In the upper jaw the teeth are small, narrow, and conical, but those of the lower jaw, which are numerous and form several series, have their points so much bent to one side that their inner margins form the cutting-edge, which is not serrated. Growing to a length of 15 feet, the Greenland shark is a determined enemy to the right whale of the same seas; and when feeding on the carcase of one of those mammals becomes so intent on its occupation as to allow itself to be harpooned without attempting to escape. Four living young are stated to be produced at a birth. Finally, we have the spiny shark (*Echinorhinus spinosus*) of the Mediterranean and Atlantic, which while agreeing with the last in the small size of the fins and the absence of spines to the dorsals, differs by the teeth being alike in both jaws, and by the presence of large rounded tubercles scattered over the skin, the body being very bulky, and the tail short. This shark lives at considerable depths, and but rarely comes to the surface.

THE EXTINCT PETALODONTS.—Family *PETALODONTIDÆ.*

The extinct genera *Petalodus* and *Janassa*, together with several other allied types from the Carboniferous rocks, represent a family apparently connecting the last with the more typical rays. In these fishes the body is moderately depressed, and the pectoral fins are large and continued anteriorly towards the head. The teeth, which generally have large roots, are compressed from front to back, with the crown more or less bent backwards and either with a sharp cutting-edge, or very blunt. In the mouth they were arranged in straight rows to form a pavement.

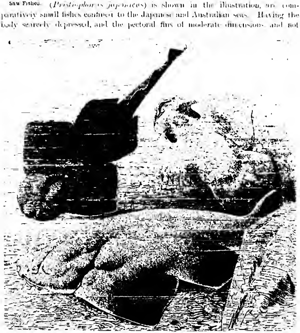
THE ANGEL-FISH.—Family *SQUATINIDÆ.*

The sole existing representative of its family, the angel-fish, or monk-fish (*Squatina vulgaris*), constitutes, so far as external form is concerned, a kind of connecting link between the sharks and the rays. Having the body as much depressed as in some of the latter, the angel-fish differs in the nearly terminal position of the mouth, and also in the circumstance that while the basal portion of the pectoral fins is much produced forwards, it does not extend so far as to join the head. The wide gill-clefts are lateral in position, and partly covered by the base of the pectoral fins; the spiracles are wide, and placed behind the eyes; and the teeth are conical and pointed. Spines are wanting to the dorsal fins, which are situated on the tail; and the skin is studded with tubercles. Not unfrequently growing to a length of at least 5 feet, the angel-fish has an almost cosmopolitan distribution, and is by no means uncommon on the British coasts, more especially in Scotland. In colour it is mottled chocolate-brown above, and whitish beneath; and except that it produces living young, which may number as many as twenty at a birth, its general habits are similar to those of the rays. Fossil species of angel-fish range through the Tertiary and Cretaceous strata to the upper Jurassic.

THE SAW-FISHES.—Families *PRISTIOPHORIDÆ* and *PRISTIDÆ.*

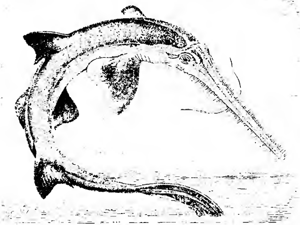
Unique among the whole class on account of the production of the upper jaw into a long flattened beak, furnished on either edge with a series of large, sharp, and pointed teeth, set in distinct sockets at a considerable distance from one another, the saw-fishes form two well-defined families, the first of which approximates to the sharks in the position of the gill-clefts, while the second agrees with the rays in the same particular. Each contains but a single existing genus, and the first is unknown previous to the present epoch.

Side-Gilled Saw Fishes. The four species belonging to the first family, one of which (*Pristiophorus japonicus*) is shown in the illustration, are comparatively small fishes confined to the Japanese and Australian seas. Having the body scarcely depressed, and the pectoral fins of moderate dimensions and not extending forwards to the head, these saw-fishes are distinguished by the lateral position of the gill-clefts, and full development of the so-called prepalatine cartilage, and the presence of a pair of long tentacles on the lower aspect of the jaw. In habits these fishes probably resemble those of the next genus.



ANGEL FISH (1/[illegible] nat. size).

True Saw Fishes. Distributed over all the warmer seas, the members of this genus, among which *Pristis antiquorum* of the Mediterranean and Atlantic is most commonly met with, differ from the last not only in the inferior position of the gill-clefts, but likewise in the small development of the prepalatine cartilages. The teeth of the saw are firmly implanted in distinct sockets of calcified cartilage, while those in the jaws are minute and blunt. The wide spiracles are situated behind the eyes; the dorsal fins are without spines, the first being placed above or near to the line of the base of the pelvic pair; and the large caudal fin may or may not have a distinct lower lobe. The saw consists internally of three, or sometimes five, hollow calcified cartilages in the form of long tapering tubes, placed side by side, and held together by integument, which is likewise more or less hardened by the deposition of calcareous matter. Several existing species of the genus have been described, which are most abundant in the tropical seas, and



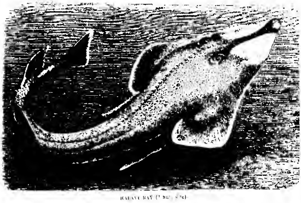
JAPANESE SAW-FISH ([illegible] nat. size)

some of which are distinguished by the shape of the caudal fin, and the number of pairs of teeth in the saw. These fishes not uncommonly grow to 20 feet in length, but Day records one of 24 feet; in such monsters the saw may be fully 6 feet in length, with a basal width of 1 foot. Some of the Indian species ascend rivers to a considerable distance beyond the influence of the tides. Saw-fishes use their weapon of offence by striking sideways through the water, and thus inflict terrific injuries, literally tearing to pieces the soft-parts of such animals as they may strike; and it is stated that in the Indian estuaries large ones have been known to cut bathers completely in two. After tearing off pieces of flesh or ripping up the body of their victim with the saw, these fishes seize and swallow the smaller fragments thus detached in their mouths. In the Malayan region the flesh of one of the species is highly esteemed as food; and its fins, like those of sharks, are after due preparation, exported to China.

Fossil remains of extinct species of the genus occur throughout a large portion of the Tertiary formations; and an allied Eocene genus, *Propristis*, differs by the circumstance that the teeth of the saw are not implanted in calcified sockets. A very remarkable type of saw-fish (*Schizorhynchus*) has left its remains in the Cretaceous rocks of Syria. Not only does this fish differ from the living forms by the distinctly depressed form of the relatively short and broad body, and the backward extension of the pectoral fins, which almost reach the pelvic pair, but the teeth, instead of being implanted in sockets, are merely attached to the skin by an expanded and enlarged base. Moreover, the central of the three rods in the interior of the saw extends to the saw's extremity, instead of stopping short; and it is not a little interesting to find that from the smaller teeth at the base of the saw a complete gradation can be traced to the tubercles dotting the skin. Assuming, as is most probably the case, that saw-fishes are nothing more than highly specialised sharks, it is somewhat remarkable to find that the earliest known member of the family has a somewhat skate-like form of body, and a type of dentition which could not apparently be very readily modified into that of the existing forms.

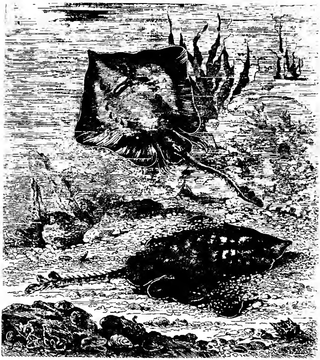
THE BEAKED RAYS.—Family *RHINOBATIDÆ*.

With this family we come to the first of what may properly be termed the rays and skates, in all of which the pectoral fins are so extended forwards as to join the head, and thus form with the body the so-called "disc"; the dorsal fins being always situated on the tail, and the mouth being generally, and the gill-clefts always, inferior. In the present family the tail is long and powerful, with two well-developed dorsal fins and a longitudinal fold on each side; the disc is not excessively dilated, the rayed portion of the pectoral fins stopping short of the beak; and there is no electric organ. Skates and rays in general are among the most hideous and repulsive of all fish, some of them—especially in the warmer seas—attaining enormous dimensions; while some are dangerous from the wounds inflicted by the spines of their tails. The tooth-like tubercles on the skin frequently attain a great development, and are aggregated into prominent bosses or longitudinal ridges. Dr. Günther writes that the mode of life of these fishes is quite in accordance with the form of their body, the true rays leading a sedentary life, moving slowly on the bottom of the sea, and rarely ascending to the surface. Their tail has almost entirely lost the function of an organ of locomotion, acting in some merely as a rudder. They progress slowly by means of the pectoral fins, the broad and thin margins of which are set in an undulating motion, entirely identical with that of the dorsal and anal fins of the *Pleuronectidæ*. Like the sharks, they are exclusively carnivorous, but being unable to pursue and catch rapidly moving animals, they feed chiefly on molluscs and crustaceans. The colour of their integuments assimilates, however, so closely to that of their surroundings, that other fishes approach near enough to be captured by them. The mouth of the rays being entirely on the lower surface of the head, the prey is not directly seized by the jaws; but the fish darts over its victim so as to cover and hold it down with its body, when it is conveyed by some rapid motions to the mouth. Rays do not descend to the same depth as sharks; with one exception, none are known to have been caught by a dredge working in more than one hundred fathoms. The majority are coast fishes, and have a comparatively limited geographical range, none extending from the northern into the southern temperate zone. Some of the eagle-rays are, however, more or less pelagic, although when these are met with swimming in the open sea it is probable that shoal-water exists at no great distance. As may be observed in many of the lochs on the west coast of Scotland, where these loathsome creatures may be seen flapping lazily along at the bottom of the clear water, skates and rays are more or less gregarious fishes. They frequently arrive suddenly on oyster-beds,—to the dismay of the owners,—where they appear to remain so long as any of the molluscs are obtainable. Writing of the species armed with caudal spines, Day observes that they "lie concealed in the sand, and are reputed to be able to suddenly encircle fish or other prey swimming above them with their long whip-like tails, and then wound them with their serrated tail-spines." Many rays ascend rivers to considerable distance, and some kinds, especially in Tropical America, are exclusively inhabitants of fresh waters. Nearly all lay eggs.



HALAVI RAY ([illegible] nat. size).

Typical Genus. To illustrate the typical genus, which is represented by about a dozen species from the warmer seas, we take the halavi ray (*Rhinobatis halavi*), which ranges from the Mediterranean and the coasts of Western Africa to China. In these fish the depressed body passes imperceptibly into the tail; the muzzle is produced into a long beak, the space between which and the pectoral fin is occupied by a membrane; and the wide nostrils are oblique, with their front valves separate. The blunt teeth are marked by an indistinct transverse ridge; the dorsal fins, which are situated far behind the pelvic pair, have no spines, and the caudal has no lower lobe. Fossil species are found from the Tertiary to the upper Jurassic. The allied Australian genus *Trygonorhina* differs in having the front nasal valves united, and forming a broad quadrangular flap.

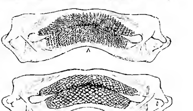


THORNBACK SKATES ($\frac{1}{7}$ nat. size).

Rhynchobatis. The third genus of the family, which is represented by two species from the coasts of the tropical portions of the Indian Ocean, differs in that the first dorsal fin is placed above the pelvic pair, in the presence of a lower lobe to the caudal, and also in the form of the dental plate, which is deeply undulated, so that the prominences of one jaw fit into hollows in the opposite one; the individual teeth being more or less diamond-shaped. These rays do not exceed 8 feet in length. Several extinct genera occur in the upper Jurassic strata of Europe.

THE TRUE RAYS OR SKATES.—Family *RAIIDÆ*.

Represented by upwards of seven British species, all of which belong to the typical genus, the true rays are characterised by the broad and rhombic form of the disc, the skin of which is generally marked with tooth-like rugosities. The tail has a longitudinal fold on each side, the degree of development of the median fins is variable, and the rayed portion of the pectoral fins extends to the muzzle. With the exception of occasional traces in the tail, electric organs are wanting. Of the typical genus we take as a well-known example the common British thornback (*Raia clavata*), of which two examples are shown in the illustration. In this genus the tail is very sharply defined from the disc, which is generally covered with rugosities; the pectoral fins stop short of the extremity of the muzzle; the pelvics are deeply notched, with a stout front cartilaginous ray; the tail carries two dorsal fins, and the caudal is rudimentary, or wanting. Most of these skates are remarkable for presenting sexual differences, which in the thornback and several other species display themselves in the dentition, the teeth of the males being sharp and pointed, while those of the opposite sex are blunt and flattened. Whereas the males of all the species are armed with patches of claw-like spines lying in grooves on the upper surface of the pectoral fins, and frequently also on the sides of the head, the females of some species have a kind of buckler of asperities on the disc, which is wanting in the other sex. In other cases the variation takes the form of a difference in colour. The numerous members of this genus are in the main characteristic of the cooler seas, and while they are more abundant in the Northern than in the Southern Hemisphere, some of them approach nearer to the Arctic and Antarctic Circles than is the case with any other rays. The flesh of all of them is eatable, that of many species being commonly sold as an article of food. The common skate (*Raia batis*), which is ordinarily of from 2 to 4 feet in length, is greyish white in colour, with black specks, the whole upper surface being more or less granulated. Buckland records an unusually large specimen which weighed 90 lbs. The thornback takes its name from having the whole of the upper surface studded at intervals with the above-mentioned claw-like spines; the tail being also armed with longer spines, of which a row runs along the middle of the back. The prevailing colour of the upper



JAWS OF MALE (A) AND FEMALE (B) THORNBACK SKATE.

surface is brown, with numerous lighter spots, while beneath it is pure white. Fossil skates of this genus range through the Tertiaries to the upper Cretaceous. At the present day the family is represented by three genera, each with but few species from the warmer seas; and there are likewise certain extinct generic types.

THE ELECTRIC RAYS.—Family *TORPEDINIDÆ.*

In common with the electric eel, the members of this family are characterised by their power of communicating galvanic shocks; the organs from which this

CUCKOO SKATE AND MARBLED ELECTRIC RAY (⅛ NAT. SIZE).

power is derived taking the form of a series of vertically-placed prisms, situated on each side of the front of the disc between the head and the pectoral fins. In addition to this distinctive feature, these rays are characterised by the broad and smooth disc, in which the rays of the pectoral fins do not extend in advance of the base of the muzzle, while the median fins are well developed. The family is represented by several genera ranging over the Mediterranean, Atlantic, and Indian Ocean, into the distinctive features of which it will be unnecessary to enter here. A well-known example of the typical genus is the marbled electric ray (*Torpedo marmorata*), represented in the lower figure of our illustration. The hexagonal prisms forming the electric organs are subdivided into a series of cells by a number of delicate transverse partitions; the cells at the two ends of the prisms being in contact with the skin, and the whole structure liberally supplied with nerves. Internally each cell is lined by a nucleated structure, within which is a mass of jelly-like substance. "The fish," writes Dr. Günther, "gives the electric shock voluntarily, when it is excited to do so in self-defence, or intends to stun or kill its prey; but to receive the shock the object must complete the galvanic circuit by communicating with the fish at two distinct points, either directly, or through the medium of some conducting body. If an insulated frog's leg touches the fish by the end of the nerve only, no muscular contractions ensue on the discharge of the battery, but a second point of contact immediately produces them. It is said that a painful sensation may be produced by a discharge conveyed through the medium of a stream of water. The electric currents created in these fishes exercise all the other known properties of electricity; they render the needle magnetic, decompose chemical compounds, and emit the spark." Specimens measuring from 2 to 3 feet across the disc are stated to be able to disable a man by the discharge of the battery. A writer in *Land and Water* for 1869, in reply to Buckland, observes that "I have taken two torpedos in the estuary of the Tees. You say the one you dissected had nothing in its stomach. I was curious enough to see what those I caught were living upon, so I put my knife into one, and took from him an eel 2 lbs. in weight, and a flounder nearly 1 lb. The next one I opened also, and was astonished to find in him a salmon between 4 and 5 lbs. weight; and what I was more astonished at was that none of the fish had a blemish of any description, showing that your idea of the fish killing his prey with his electrical force is quite correct."

THE EAGLE-RAYS.—Family *MYLIOBATIDÆ*

Known also by the ill-sounding title of devil-fishes, the eagle-rays include the largest representatives of their tribe, and are characterised by the extreme width of the disc owing to the great development of the pectoral fins, which are, however, interrupted at the sides of the head, to reappear as one or two small cephalic fins on the muzzle. The tail is slender and whip-like, the cleft of the mouth straight, and the teeth, when present, take the form of a solid pavement adapted for crushing the shells of molluscs, and other hard substances. The eagle-rays are inhabitants of tropical and temperate seas; and the members of some of the genera are remarkable for the development of the so-called cephalic fins into a pair of horn-like appendages, which are stated to be employed in capturing the prey and helping to convey it to the mouth. Five genera are included in the family, all the members of which appear to be viviparous.

Typical Genus. The typical genus is represented by a small number of existing species, two of which are European; one of these, *Myliobatis aquila*, occasionally visiting the British coasts, where it is often termed **the whip-ray.** In this group the head is free from the disc, and the fin on the **muzzle single.** The large, flat hexagonal teeth form a tesselated pavement, highly **convex in the** upper, but flat in the lower jaw; the individual teeth **are arranged in seven** longitudinal rows, those of the unpaired middle row being much **elongated and** transverse, while the others form less irregular hexagons. **The whip-like tail, in** addition to a dorsal fin near the root, is generally armed **with a large barbed spine** about the middle of its length. In the young the middle row of teeth **are not** larger than the lateral ones, and their relative width continues to increase throughout life. The species above named, which has an almost cosmopolitan distribution, may attain to a length of upwards of 15 feet, with a weight of about 800 lbs. When captured, these rays lash out with their tails, and thus inflict severe wounds with the spine. Fossil species of this genus occur through most of the Tertiary strata; and among these one from the Eocene of Egypt is remarkable for its enormous size, the teeth of the middle row being rather more than 5 inches in width. Although it is difficult to form an estimate of the exact size of the fish to which these teeth belonged, it is thought that the width of the disc must have been about 15 feet.

Other Genera In the allied genus *Aetobatis*, now represented by a single widely-spread tropical species but common in the Tertiary formations, the muzzle carries two fins, and the dentition comprises only a single series of transversely elongated teeth, corresponding to the central row of the typical genus. In a third genus (*Rhinoptera*), of which there are seven living and several Tertiary species, the so-called fins on the muzzle are likewise double, while the tesselated teeth form five or more series. Of these the middle one is the largest, the first, or first and second, lateral series somewhat narrow, and the remainder in the form of more or less nearly regular hexagons; the dental plates of both jaws being strongly arched from back to front. The largest existing members of the family belong to the genera *Dicerobatis* and *Cephaloptera*, which are mainly confined to the tropical seas, and to which the name of devil-fish might well be restricted. In the former of these the pectoral fins do not extend on to the sides of the head, which is truncated in front, and furnished with a pair of forwardly-directed appendages containing fin-rays, the nostrils being widely separated. Both jaws contain numerous rows of flat or tuberculated teeth; and the whip-like tail has a single dorsal fin above and between the pelvic pair, and may be armed with a spine. In the second genus the mouth is terminal, and teeth are present only in the lower jaw. One of the Indian representatives of the first genus is known to measure fully 18 feet across the disc, and a weight of over 1200 lbs. has been recorded. Sir W. Elliot states that the horn-like appendages "are used by the animal to draw its prey into its mouth, which opens like a huge cavern between them. The fishermen [in India] say they see these creatures swimming slowly along with their mouths open, and flapping these great sails inwards, drawing in the smaller crustaceans on which they feed." The capture of such hideous monsters is a work of no little difficulty and danger, as they are quite capable of overturning a boat; and the danger is said to be the greatest in the case of a female accompanied by its single offspring. We must not leave this family without referring to the curiously-ridged quadrangular teeth from the Chalk described under the name of *Ptychodus*, which appear to indicate an extinct type of eagle-ray. In these teeth the highly-polished crown is ornamented with large transverse or radiating ridges, surrounded by a more finely-marked marginal area of variable width. They are arranged in longitudinal rows; the upper jaw having the teeth of the middle row the largest, and those of the lateral rows gradually decreasing in size; while in the lower jaw the middle teeth are rather small, and the two adjacent rows the largest.

THE STING-RAYS.—Family *TRYGONIDÆ*.

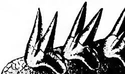
Apparently the most specialised members of the entire group are the sting-rays, in which the pectoral fins are continued uninterruptedly round the extremity of the muzzle, so that the whole of the margin of the very wide disc is formed by these fins, in the centre of which is the more elevated head and body. The long and slender tail, which is frequently armed with a serrated spine, is sharply defined from the body; and the median fins, if present at all, are either imperfectly developed, or are modified into serrated spines. The forms with armed tails, to which the name of sting-ray is alone strictly applicable, inflict very severe wounds, dangerous not merely from the actual lesion, but apparently also from the presence of some poisonous substance. In the larger kinds these formidable spines may be as much as 8 or 9 inches in length; and, as they wear out, they are from time to time shed and replaced by new ones growing from behind. Very numerous in species, and arranged under several genera, the sting-rays are most abundant in the seas of the tropics, although some range into temperate waters.

The typical genus includes some twenty-five species, one of which (*Trygon pastinaca*) ranges from the south of England westwards to America and eastwards to Japan. In this group the greatly elongated and tapering tail is armed with a barbed arrow-shaped spine, while the skin is either smooth or dotted over with tubercles, the nasal valves unite to form a quadrangular flap, and the teeth are flattened. Mainly characteristic of tropical latitudes, these rays are most abundant in the Indian and Atlantic Oceans, although some species are inhabitants of fresh-water lakes in Eastern Tropical America. The rough ray (*Urogymnus asperrimus*), of the Red Sea and Indian Ocean, which may measure from 4 to 5 feet in length from the head to the root of the tail, is the sole representative of a second genus, characterised by the long tail being devoid of either fin or spine, although sometimes furnished with a narrow fold of skin below. The whole of the body is thickly covered with teeth-like tubercles, the teeth themselves being flattened. The third genus (*Urolophus*)—in which the tail is of medium length, furnished with a distinct terminal rayed fin, armed with a barbed spine, and sometimes with a rudimental dorsal fin, while the teeth are flattened—contains several rather small-sized species from the tropical seas, and likewise an extinct one from the Eocene rocks of Italy. A fourth genus (*Pteroplatea*), of which there are some half-dozen representatives from temperate and tropical seas, is characterised by the great width of the disc, which is at least twice as long as wide, and also by the shortness of the thin tail, which always bears a serrated spine, and may have a rudimental fin, the minute teeth being either singly or triply cuspidate. The oldest representative of the family seems to be the extinct *Cyclobatis* from the Cretaceous rocks of Palestine, in which the disc is either circular or oval in form, the tail very short, only slightly projecting beyond the margin of the disc, and devoid of either spine or fin, while the upper surface of the body has one or more longitudinal series of large spiny tubercles running backwards from the pectoral girdle, the remainder of the body and disc being more or less sparsely covered with minute prickles.

The Extinct Lobe-Finned and Fold-Finned Sharks,—Orders Ichthyotomi and Cladodontia

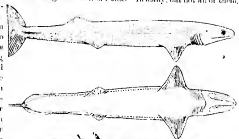
The whole of the preceding members of the subclass are included in a single order, the characters of which have been already described; but in the Palæozoic strata of both Europe and the United States there occur remains of extinct sharks indicating two perfectly distinct ordinal groups.

Lobe Finned Group. The essential characteristic of this group, as shown in the restored skeleton figured on p. 317, is the lobed structure of the pectoral fins which consist internally of a long tapering segmented axis, from which are given off a double series of cartilaginous rays as shown in the figure on p. 319. The internal skeleton of these sharks shows granular calcifications in the cartilage; but the notochord is never or but seldom constricted into distinct vertebræ, the ossification, except in the tail, stopping short at an incomplete stage, when the body of each segment of the backbone consists of three separate pieces, as in the example figured on p. 312. The upper and lower arches and spines of the backbone are tall and slender, the upper spines having no intercalary cartilages between them. As represented by the genus *Pleuracanthus*, common to the Permian and Carboniferous rocks of both sides of the Atlantic, these sharks are further characterised by the slender and slightly depressed form of the body, the terminal position of the mouth and the diphycercal tail. The long and low dorsal fin is continued along the whole of the back from a short distance behind the head, and its cartilages are more numerous than the subjacent spines of the vertebræ; immediately behind the head is a long barbed spine, and the body was probably devoid of shagreen. The teeth, as shown in the annexed illustration, are very peculiar, consisting of two divergent and generally unequal-sized cones, supported on an expanded base.



TEETH OF A LOBE-FINNED SHARK.—After Fritsch.

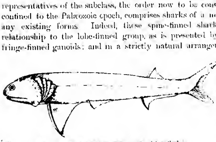
Fold-Finned Group. The oldest and most primitive representatives of the entire subclass are the armoured sharks of the Devonian and lower Carboniferous epochs, especially characterised by the simple structure of their fins which, as explained on p. 319, are of the fold-type, and consist simply of a series of parallel cartilaginous rods arising from a broad base. In many, but not all of them, the granules constituting the shagreen of modern sharks coalesced so as to form large shields protecting the body; and these fish were also armed with more or less markedly triangular spines inserted in the skin by their bases. In some cases the teeth consisted of a single cone, with one small basal cusp, but in other forms they seem to have coalesced into a pavement-like structure. No traces of calcification have been detected in the notochord. As might have been expected, these primitive sharks were of comparatively small size, averaging from 3 to 4 feet in length.



RESTORATION OF A FOLD-FINNED SHARK (*Cladoselache*). After Dean.

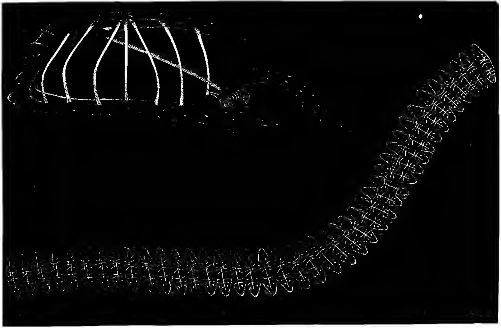
THE EXTINCT SPINE-FINNED SHARKS,—Order ACANTHODII.

Whereas the two preceding groups contain the most primitive and generalised representatives of the subclass, the order now to be considered, which is likewise confined to the Palæozoic epoch, comprises sharks of a more specialised type than any existing forms. Indeed, these spine-finned sharks bear much the same relationship to the lobe-finned group, as is presented by the bony fishes to the fringe-finned ganoids; and in a strictly natural arrangement these forms should stand at the head of the class, although it is more convenient to consider them in this place. One of the essential features of the group is to be found in the development of membrane-bones overlying the original cartilaginous skull; the socket of the eye being also frequently surrounded with a ring of bones of similar origin. In the internal skeleton the notochord is persistent, and the cartilages are superficially calcified, frequently with a granular structure. When teeth are present, these are firmly fixed upon membrane-bones overlying the cartilages corresponding to the functional jaws of other sharks. The gill-arches bear a series of



RESTORATION OF A SPINE-FINNED SHARK (*Acanthodes*).
(From A. S. Woodward, *Cat. Fos. Fish Brit. Mus.*)

appendages which during life were probably furnished with membranous expansions similar to those of the existing frill-gilled shark. In the fins the cartilages of the internal skeleton are greatly reduced, and the membranous portions are almost destitute of cartilaginous rays, while each of the paired and most of the median fins are provided with a large spine on the front edge. The tail is of the heterocercal type, and the males lack the claspers characterising the existing forms. Externally the body is covered with small and closely-arranged quadrangular granules, between two series of which runs the lateral line. Three families constitute the order; the first of these, as represented by the genus *Acanthodes*, having but a single dorsal fin, while in the other two—respectively typified by *Ischnacanthus* and *Diplacanthus*—there are two of these fins.



ASCIDIANS

SOLITARY SALPA AND CHAIN SALPA

THE LOWEST VERTEBRATES AND THEIR ALLIES.

CHAPTER I.

THE LAMPREY GROUP,—Class **Cyclostomata.**

TILL within recent years both the lampreys and the strange little creature known as the lancelet were generally included among the class of fishes, which was also taken to comprise a number of armoured extinct forms, of which a brief notice is given below. On the other hand, the marine animals commonly termed sea-squirts, but technically known as ascidians, together with certain aberrant worm-like creatures, were classed with the great assemblage of so-called Invertebrates. Anatomical and palæontological investigations have, however, revolutionised our ideas concerning the creatures in question, with the result that while the lampreys are now separated from the fishes to form a class by themselves in the vertebrate subkingdom, the lancelet and sea-squirts, together with the above-mentioned worm-like creatures are now regarded as forming a subkingdom by themselves, known as the Semivertebrates, or Protochordata. The reason for the separation of the lampreys from the fishes will be gathered when we come to that group; but we must briefly notice in this place the considerations which have induced naturalists to brigade in one group such very dissimilar creatures as the lancelet, sea-squirts, and the aforesaid worms.

In the introduction to the Vertebrates given in the first volume we have indicated the leading structural features of that group—more especially as developed in its higher members; among these one of the most important being the dorsal position of the great nervous system, or spinal marrow, which in the higher forms is underlaid by the bodies of the vertebræ. In our description of the fishes we have, however, seen that in some of the lower forms the vertebræ are represented only by the original cartilaginous rod known as the notochord, from which they are developed by constriction in the higher types. To this we have to add that in the earlier stages of their development all vertebrates possess gill-slits, which persist in their original condition only in the fishes and lampreys. Now the result of anatomical investigations has been to show that the lancelet, sea-squirts, and the aforesaid worm-like creatures agree with the Vertebrates in the possession of a dorsally-situated nervous system, of a notochord, and of gill-slits; and thereby differ from all other known animals. Consequently we may classify the animal **kingdom as** follows:—

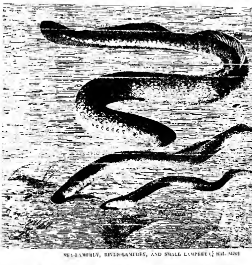
I. Chordate Animals.—Division Chordata { Nervous System Dorsal, a Notochord, and Gill Slits.
  1. Vertebrates—Subkingdom Vertebrata.
    (1) Mammals—Class Mammalia.
    (2) Birds—Class Aves.
    (3) Reptiles—Class Reptilia.
    (4) Frogs and Salamanders—Class Amphibia.
    (5) Fishes—Class Pisces.
    (6) Lampreys and Hag-Fishes—Class Cyclostomata.
  2. Semivertebrates—Subkingdom Protochordata.
    (1) Lancelets—Class Leptocardii.
    (2) Sea-Squirts—Class Tunicata.
    (3) Worm-Like Forms—Class Enteropneusta.
II. Non-Chordate Animals.—Division Invertebrata { Nervous System Ventral, no Notochord or Gill Slits.

We shall consider briefly the suggestions that have been made concerning the relationships between the semichordates and nonchordates at the close of this volume, and therefore proceed at once to the lampreys. Before doing so it may, however, be as well to mention that to rightly understand the peculiarities of all these matters requires a considerable amount of anatomical knowledge on the part of the reader; and structural features will accordingly be alluded to as simply and shortly as possible.

THE LAMPREYS AND HAG-FISHES,—Subclass **Marsipobranchii**.

As a class the lampreys and their near allies the hag-fishes, with which may probably be grouped certain armoured extinct forms, are distinguished not only from the fishes, but likewise from all the vertebrates hitherto described, by the absence of true jaws, by the single aperture of the nostrils, as well as by the rasping tongue; there being no limbs or ribs, and the notochord either persisting in its original form or being merely surrounded by a series of calcified rings. Probably many or all of these characters are applicable to certain extinct forms now considered as more or less nearly allied to the lampreys, and we may accordingly provisionally regard these as distinctive of the subclass. On the other hand, we may consider the under-mentioned features distinctive of the lampreys as the representatives of a subclass (Marsipobranchii), apart from the aforesaid extinct forms. In the existing members of the group the skeleton is cartilaginous; the skull, as in the chimæroid fishes and some of the sharks, is immovably joined to the vertebral column; and the gills are in the form of fixed pouches (hence the name of the subclass), without gill-arches and either six or seven in number, with their external apertures usually opening on the sides of the neck. Anterior in position, and adapted for sucking, the mouth is surrounded by a circular or subcircular lip supported by cartilages. The naked body is provided with median fins having cartilaginous rays like those of many fishes. Internally, the heart is devoid of the anterior expansion known as the bulbus arteriosus; the intestinal canal is straight and simple; and the reproductive organs discharge into the cavity of the body. The place of teeth is taken in some forms by horny structures, while in others the mouth is completely unarmed. Some difference of opinion exists among naturalists as to whether the absence of the true jaws in the lampreys is an original or an acquired feature; but, to our mind, the apparent want of these organs in the primitive extinct lampreys seems to be strongly in favour of the former view.

True Lampreys. The true lampreys, of which the sea-lamprey (*Petromyzon marinus*), river-lamprey (*P. fluviatilis*), and the small lamprey (*P. branchialis*) occur in Britain, are the typical representatives of a family (*Petromyzidæ*) characterised by the nasal duct terminating in a closed sac behind, without perforating the palate. As in all the other members of the group, the naked body is eel-like in form; but the family is peculiar in that its members undergo a metamorphosis, the young being devoid of teeth and furnished with a single median fin, whereas in the adult the sucking-mouth is furnished with horny teeth resting on a soft cushion, and the median fin is divided. In the adult the tongue is furnished with rasping teeth, while above and below the aperture of the mouth there are a series of upper and lower teeth, and the sucking disc is likewise provided with smaller isolated teeth. Eyes are present in the adult; and the aperture of the nostrils is situated in the middle of the head. The seven-gill pouches open externally by as many apertures on each side of the neck, but com-

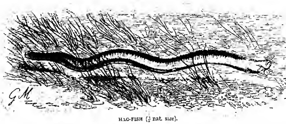


SEA-LAMPREY, RIVER-LAMPREY, AND SMALL LAMPREY (¼ nat. size) municate with the pharynx by a common opening to which the ducts of all converge. The intestine is furnished with a spiral valve, and the eggs are minute.

The true lampreys are characterised in the adult condition by having two dorsal fins, the hindmost of which is continuous with the caudal; and likewise by the upper series of oral teeth consisting either of a doubly-cusped transverse ridge, or of two closely-placed separate teeth; while the teeth on the tongue are serrated. The genus appears to be represented by four species, which are confined to the coasts and fresh waters of the Northern Hemisphere, ranging as far south as West Africa. The largest of these is the sea-lamprey, represented in the upper figure of our illustration, which may grow to as much as a yard in length, and is common to Europe, North America and West Africa. On the other hand, the river-lamprey, or lampern, which at certain seasons ascends the rivers of Europe, North America, and Japan in innumerable hosts, is somewhat less than two feet in length, and differs from the last species in being uniformly coloured, instead of marbled with black. Still smaller is the small lamprey, also known as the pride or sand-piper, which is likewise common to Europe and Western North America, and scarcely reaches one foot in length; its coloration being uniform. The young of this form was long regarded as a distinct genus, under the name of *Ammocoetes*; but its true nature was discovered by watching the transformation into the adult. The larva, writes Dr. Günther, requires three or four years for its full development. At first the head is very small, and the cavity of the mouth "surrounded by a semicircular upper lip, the separate lower lip being very small. There are no teeth, but several fringed barbels surround the mouth. The extremely small eyes are hidden in a shallow groove; but there is a median single nasal opening, and seven gill-openings, as in the adult. The vertical fins form a continuous fringe, in which the later divisions are more or less distinctly indicated." When open, the mouth of lampreys is nearly circular in shape, but when closed forms a narrow slit.

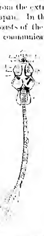
Much has still to be learned regarding the habits of lampreys, but it appears that all the members of the present genus ascend rivers for the purpose of spawning, and that some of them pass the whole of their larval conditions in fresh waters. They are all carnivorous, and in the adult state attach themselves by their mouths to the bodies of fishes, from which they rasp off the flesh with their horny teeth; fish being not unfrequently met with bearing the scars of wounds thus inflicted, and a salmon has been taken high up in the Rhone with a sea-lamprey tightly adhering to its side. Bathers have also been known to be attacked by the same species. Commonly keeping to the bottom, the sea-lamprey may at times be seen swimming near the surface with a serpentine movement of the body. In the Severn the capture of this species lasts from February to May, while in the Thames the season is May and June; but in the Scottish rivers the lampreys do not ascend till the end of June, remaining till the beginning of August. During the spawning-season these fishes excavate furrows in the river-bottoms for the reception of their eggs, and are said to remove impeding stones by lifting them up with their sucking mouths. Being much exhausted by the function of spawning, at its conclusion they make their way with all speed to the sea. The river-lamprey was at one time thought to be a permanent inhabitant of fresh waters, but it has been taken in the sea, and it has even been considered that it may undergo its metamorphosis in salt water. Always restricted to low-lying countries, this lamprey may be found alike in rivers, streams, lakes, and marshes, although it only spawns where the water is clear and flows swiftly over a stony bed. During the spawning-season, which takes place in March and April, the lampreys acquire a brilliant metallic lustre, while at the conclusion of the function they generally perish. Formerly these lampreys occurred in enormous quantities in many of the English rivers, upwards of three thousand having been taken at Newark in a single night; but the numbers in the Thames are now considerably diminished. Their chief use is as bait for cod and other fish; for which they are specially adapted on account of the ease with which they can be kept alive. There is nothing calling for special notice with regard to the habits of the small lamprey.

Southern Lampreys. In the Southern Hemisphere the family is represented by three genera, in one of which there is a single species (*Mordacia mordax*) common to the coasts of Chili and Tasmania, while in a second (*Geotria*) there is one Chilian and another South Australian species. The first of these two genera agrees with the typical representatives of the family in the continuity between the second dorsal and caudal fins, but differs in having two groups of three-cusped teeth above the aperture of the mouth; whereas in the second genus the two fins above-mentioned are separate, and there is a four-lobed plate above the mouth. Some of these lampreys grow to a length of a couple of feet; and in the adults of some or all of them the skin of the throat is so much expanded as to form a kind of pouch. The third genus (*Exomegas*) appears to be known only by two examples from the Atlantic side of South America, one of which was picked up in the streets of Buenos Aires in 1867, while the second was obtained from the Bay of Monte Video in 1890. With the exception that the dentition is of a peculiar type, very little is known as to the structure of this rare form. It will not fail to be noticed that the remarkable geographical distribution of these southern lampreys is paralleled by that of certain fresh-water fishes already described, with the exception that there is no instance among the latter where a species is common to Australia and South America.



HAG-FISH (½ nat. size).

Hag-fishes. The hag-fishes, of which there are two genera, constitute a family (*Myxinidæ*) distinguished from the last by the nasal sac having a posterior duct which perforates the palate; the single external nasal aperture being situated above the mouth at the extremity of the head, which is furnished with four pairs of barbels. The mouth is devoid of lips, the palate is provided with a single median tooth, and there are two comb-like series of rasping teeth on the tongue. The gill-apertures, or aperture, are situated at a considerable distance from the head; and each gill-pouch has a separate duct opening into the œsophagus. The sides of the abdomen carry a row of mucous sacs, and there is no spiral valve to the intestine. The large eggs are invested in a horny envelope, furnished with threads for adhesion. In the true hag-fishes, of which the common species (*Myxine glutinosa*) is found on the coasts of Europe and North America, there is but a single gill-opening on each side of the abdomen, leading by means of six ducts to as many gill-pouches. Another species has been recorded from the extremity of South America; and the range of the genus also includes Japan. In the second genus (*Bdellostoma*) of which there are two species from the coasts of the South Pacific there are six or more gill-openings on each side, each communicating by a separate duct with a gill-chamber. All these creatures are marine, and are frequently found deeply buried in the bodies of fishes, more especially members of the cod family, into which they bore for the purpose of feeding on the flesh. They are totally blind, and secrete vast quantities of slime, which seriously interferes with fishing in localities where these creatures abound. Met with in the fjords of Norway at a depth of about 70 fathoms, hag-fishes have been dredged from depths of nearly 350 fathoms.



SKETCH OF [illegible] RESTORATION OF THE SKELETON OF THE PRIMEVAL LAMPREY.—After Traquair.

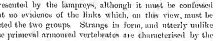
Primeval Lampreys. The Old Red Sandstone of Caithness has yielded the skeletons of a small limbless creature (*Palæospondylus*) which there is little doubt must be regarded as one of the forerunners of the modern lampreys. Measuring only about a couple of inches in length, these skeletons show a well-calcified skull, while the notochord is surrounded by a series of calcified rings, and the tail has a large fin, of which the supports on the upper side are forked like those of lampreys. The front of the head has a circular opening surrounded with a ring of tentacles (*dt*, *lt*) probably corresponding to the nose of a modern lamprey; the opening of the nose itself (*n*) appears to be single; and there are a pair of plates (*r*) behind the head not improbably representing gill plates. It may be confidently assumed that this little creature is but one among a series of lost types.

CHAPTER II.

THE ARMOURED PRIMEVAL VERTEBRATES,—Subclass OSTRACOPHORI.

A GROUP of remarkable armoured forms from the Palæozoic rocks formerly placed among the fishes, are now regarded as probably constituting a subclass of the class typically represented by the lampreys, although it must be confessed that we have at present no evidence of the links which, on this view, must be supposed to have connected the two groups. Strange in form, and utterly unlike any living animals, these primeval armoured vertebrates are characterised by the great development of the external skeleton, the head and fore-part of the body being protected by large bone-like plates. There are no hard structures to the mouth, and there are, at most, but rudimental indications of arches for the support of limbs, while the notochord is persistent. They may be divided into three chief groups; and one of the most curious features connected with the first of these is the apparent structural identity of one layer of its shield with a layer found in the investment of the living king-crabs.

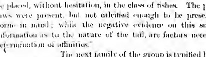
Pteraspis. The simplest of these armoured forms is typified by the genus *Pteraspis* of the Devonian rocks, a partial restoration of which is given in the annexed figure. In these creatures the head and fore-part of the body are protected both above and beneath by shields; while the tail, in some cases at least, is scaled. The structure of the shield is curious, each plate consisting of an outer and inner hard layer, between which is a thick stratum of polygonal chambers, perforated by delicate tunnels of the sensory canal-system of the skin; all the layers lacking the elements of true bone, and the outer surface being marked with fine concentric striæ. The eyes are lateral and widely separated, and towards the hinder end of the back shield (which is provided with a spine) there is an aperture on each side for the escape of water from a gill-cavity. Although nothing is known as to the form and structure of the nose and mouth, the nostrils must evidently have been placed near the mouth on the under surface of the head. A pit between the eyes probably marks the site of a rudimental median eye; and the structure of the under surface of the shield indicates the presence of separated gill-pouches, which were probably supported by arches. From an examination of the whole structure of the remains Mr A. S. Woodward is of opinion that the shield probably covered "a truly fish-like head;



PARTIAL RESTORATION OF *Pteraspis*.
(From A. S. Woodward, *Cat. Foss. Fish Brit. Mus.*)

and if it was not for the invariable absence of limbs and jaws, and the forward position of the breathing apparatus in *Pteraspis* and its allies, these animals might be placed, without hesitation, in the class of fishes. The possibility that limbs and jaws were present, but not calcified enough to be preserved, must, however, be borne in mind; while the negative evidence on this subject, and the want of information as to the nature of the tail, are factors necessitating caution in the determination of affinities."

Cephalaspis. The next family of the group is typified by the genus *Cephalaspis* in which the front shield appears to be confined to the head and gill-region, and consists of a single piece, rounded or pointed in front, abruptly truncated behind, and with the rounded margin bent inwards below to form an ornamented flattened rim. Of the triple-layered shield, the inner layer is bony, the thick middle one solid, although traversed by a network of blood-vessels, while the upper one is tuberculated and resembles teeth in structure. The eyes are placed close together in the middle of the shield, the nostrils must have had much the same position as in *Pteraspis*, and at the back of the shield there occurs on each side a small flap which must be regarded as a gill-cover. Immediately behind the shield commences the ordinary scaling of the body, without any signs of arches for the support of limbs. Paired fins appear, indeed, to be totally absent, although a dorsal and a caudal fin, stiffened by little elongated scales in place of rays, are present. The large, deep, quadrangular scales covering the body form a series of interlocking rings, doubtless corresponding in the living state to the underlying muscle-plates of the body.



RESTORATION OF *Cephalaspis*. (From Woodward, *Cat. Foss. Fish. Brit. Mus.*)

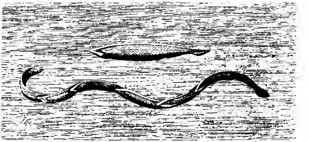
Pterichthys. The third modification of the group, as represented by the Devonian *Pterichthys* agrees in the general structure of the shield with certain members of the last section in which there is no dividing line between the head-shield and the united scales of the body. The head is, however, sharply defined from the body; and the armour, instead of being simple, consists of a number of overlapping plates arranged symmetrically to one another. An important point of distinction from all the preceding forms is to be found in the presence of a pair of hollow limb-like pectoral appendages, jointed near the middle. A small movable plate between the eyes seems to have lodged a median eye; another movable plate on the cheek appears to represent the gill-cover; and a pair of loose jaw-plates on the lower surface of the front of the head, in some forms at least, are finely toothed on the hinder border; but nothing definite is known with regard to the nature of the nose, mouth, and jaws.

RESTORATION OF PTERICHTHYS. (From Traquair.)

The arrangement of the median fins is generally similar to that obtaining in the second family. With regard to the true nature of the pectoral appendages, Mr. Woodward writes that they are commonly considered "as homologous with the paired pectoral fins of fishes, and certainly in their mode of fixation to the trunk there is much to favour that supposition; but the discovery of an allied organism in the Devonian of Spitzbergen suggests the wisdom of suspending judgment. The dorsal body-shield of the latter is simpler than that of *Pterichthys*, but the arrangement of the plates on the ventral aspect is identical, and there are also hollow pectoral appendages. These appendages, however, are merely simple triangular spines, firmly fixed by suture to processes of the body-armour; and if they are an inferior or special condition of the ordinarily movable arms, it seems not unlikely that those arms will prove to be different in origin from the paired limbs of fishes."

CHAPTER III.

The Lancelets,—Subkingdom **PROTOCHORDATA**.
Class **Leptocardii**.



COMMON LANCELET, SINGLY, AND IN A CHAIN (nat. size).

With the curious semitransparent little creatures known as lancelets, forming the only family (*Branchiostomatidæ*) and genus of the class to which they belong, we leave the Vertebrates and come to the lower group of Protochordates; all of which retain the three essential vertebrate features mentioned on p. 549. First described by the German naturalist Pallas in 1778 from a specimen captured on the Cornish coast, the common lancelet (*Branchiostoma lanceolatum*) was referred to that refuge for the destitute, the Mollusca, where it remained till 1834, when it was rediscovered by Costa on the Neapolitan coast, who gave the name of *Branchiostoma*, and placed it among the fishes, in the neighbourhood of the lampreys and hags. It was again discovered by Yarrell in 1836, who assigned the title of *Amphioxus*, and was the first to recognise the existence of a cartilaginous vertebral column or notochord. The upper figure of our illustration shows the pointed extremities of the body, and also a number of chevron-shaped lines, with their angles directed forwards, these being the partitions dividing the longitudinal mass of muscle clothing each side of the body into a series of segments. And it is due to this segmented structure that the lancelet is enabled to swim so speedily as it does, its progress being effected by serpentine movements of the body. Paired fins are wanting; but the back is provided with a continuous dorsal fin, expanded posteriorly into a caudal fin, and continued forwards to join the ring of feelers, or tentacles, growing from the margin of the hood-like expansion of skin which surrounds the mouth. The notochord extends to the anterior and posterior extremities of the body, reaching beyond the muscle-plates, and likewise in advance of the front extremity of the overlying nerve-chord; the latter feature being peculiar to the lancelet. An aperture distant about two-thirds of the whole length from the head, and opening in the middle line of the lower surface of the body, is the outlet of a large cavity, or atrial chamber, surrounding most of the internal organs and especially the large pharynx; and the vent, as in many tadpoles, is situated high up on the left side, near the hinder end of the body. The reproductive organs, which form oval structures lying below the muscle-plates, differ from those of the Vertebrates in that they consist of a large number of perfectly distinct chambers, corresponding to the muscle-segments of the region of the body along which they extend. In connection with the fins, it should be observed that, except at its two extremities, the dorsal fin is supported by a series of gelatinous rays, each lying in a chamber of its own; while the ventral portion of the caudal fin has a paired series of similar supports. In young and transparent examples the pharynx, or that portion of the alimentary tract immediately behind the mouth, is distinctly visible through the walls of the body, and can be seen to be perforated on each side by a very large number of vertical gill-slits, opening into the atrial chamber. In the living creature an almost continuous current of water is drawn, for the purpose of breathing and feeding, through the mouth into the pharynx, whence it escapes by means of the gill-slits into the atrial chamber, from which it is discharged through the pore. Unlike even the lowest Vertebrates, lancelets have no cartilaginous skull; the only solid structure in the head taking the form of a ring of cartilage in the hood surrounding the mouth, which gives off a series of processes for the support of the feelers. Although paired eyes, as well as organs of hearing, are totally wanting in these strange little creatures, a pigment-spot at the front end of the nerve-tube represents a median eye; behind which is a small nasal pit, communicating in the larva by means of a small pore with the front of the nerve-tube. With regard to the other soft-parts, it will suffice to mention that the anterior extremity of the nerve-tube is not expanded to form a true brain; and that the heart is represented merely by a series of pulsating dilatations of the great blood-vessel, the blood itself being devoid of colour.

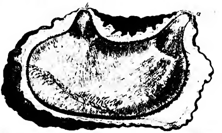
Lancelets are represented by some eight or nine species, all of which may be included in a single genus; although one from the Bahamas is peculiar on account of the unsymmetrical arrangement of its reproductive organs. Essentially littoral forms, inhabiting shallow water, especially where the bottom is sandy, these creatures have an almost universal distribution on the temperate and tropical coasts, although they are often curiously local. The European form has been recorded from Scandinavia, Heligoland, the English Channel, France, the Mediterranean, and Chesapeake Bay, growing to an unusual size in French waters. Other species occur on the Atlantic and Pacific shores of North and South America, as well as on the coasts of Australia, Japan, Ceylon, and the Fiji Islands. Mr. A. Willey remarks that the lancelet "possesses an extraordinary capacity for burrowing in the sand of the seashore or sea-bottom. If an individual be dropped from the hand on to a mound of wet sand, which has just been dredged out of the water, it will burrow its way to the lowest depths of the sand-hillock in the twinkling of an eye. Its usual *modus vivendi* is to bury the whole of its body in the sand, leaving only the mouth with the expanded buccal cirri [tentacles] protruding. When obtained in this position in a glass jar, a constant inflowing current of water, in which food-particles are involved, can be observed in the neighbourhood of the upstanding mouths. The food consists almost entirely of microscopic plants (diatoms, desmids, etc.) and vegetable débris. . . . Occasionally it emerges from its favourite position in the sand, and after swimming about for some time it will sink to the bottom, and there recline for a longer or shorter period upon its side on the surface of the sand. When resting on the sand, it is unable to maintain its equilibrium in the same position as an ordinary fish would do, but invariably topples over on its side,—indifferently the right or left.” this inability to maintain its balance being due to the absence of certain structures of the internal ear, to which this function is assigned in fishes. According to another observer, lancelets occasionally attach themselves to another by their mouths in a chain-like manner, as represented in our illustration. That lancelets indicate an extremely archaic type, and also that they are more nearly allied to the Vertebrates than to the Invertebrates, may be considered certain; although there is still a difference of opinion whether they should be looked upon as simple or degraded forms.

CHAPTER IV.

THE SEA-SQUIRTS OR ASCIDIANS,—Class **Tunicata**.

A LEATHERY, FIXED SEA-SQUIRT. *Microcosmus* (nat. size).

EXTERNALLY, scarcely any creatures are more unlike the lancelet than those fixed marine animals commonly known as sea-squirts, and technically as ascidians, or tunicates. Nevertheless, in the opinion of those best qualified to judge, the relationship is probably closer than that existing between the former animal and the larva of a lamprey, in spite of the much greater external resemblance between the two latter. It is, however, when we dissect a sea-squirt that we meet with structures recalling certain features in the anatomy of the lancelet; while to find evidence of the chordate affinities of the former we have to go back to its larval condition. In the adult condition, writes Mr. Willey, most of the sea-squirts "are sedentary animals, remaining fixed for their lifetime on one spot, whether attached to rocks, stones, shells, or seaweeds, from which they are incapable of moving. There are, however, several very extraordinary genera of ascidians which swim or float about perpetually in the open ocean, and have become adapted in the extremest manner to a purely pelagic environment.” As there are both simple and compound fixed ascidians, so there are two similar types among the pelagic forms; but some of the latter are complicated by an alternation of generations, the one generation being a simple form, whereas in the other generation the units are aggregated into chains, as shown in our Plate of the creatures known as salpæ. Among the compound fixed types the colonies, as they are termed, consist of a number of individuals produced by budding from a single parent-stock; such colonies frequently attaining very large dimensions, and being remarkable for their brilliant coloration, although in other cases they merely form thin incrustations on the surface of various marine objects. Other forms, on the contrary, are merely connected at their bases by a common creeping root-like base, from which new buds are from time to time given off, the individuals being otherwise free.[1]



A LEATHERY SEA-SQUIRT, WITH ONE SIDE OF THE OUTER TUNIC REMOVED (NAT. SIZE).

Structure of Ascidians.

Externally a simple sea-squirt, like the one (*A. microcosmus*) represented in the first illustration, has been aptly compared to a leather bottle with two spouts, these spouts forming funnel-shaped projections, one of which—generally situated at a higher level than the other—takes in water, which is discharged from the second. The whole organism is invested in an external tunic, varying much in structure, but being frequently warty, and generally opaque, although in the salpæ it is transparent. A remarkable feature connected with this outer tunic is that it contains a substance—cellulose—identical in composition with that forming the cell-walls of plant-tissues. On cutting through the outer tunic, we come, as in our second illustration, to an underlying muscular tunic, forming the true body-wall, and consisting externally of an epidermis underlain by interlacing muscular fibres. In the illustration *a* indicates the inhalent, and *b* the exhalent orifice of this inner tunic. On cutting into the inner tunic we find a large so-called atrial cavity, enclosing to a great extent the viscera, and communicating with the exterior by means of the exhalent orifice. The inhalent orifice, or mouth, communicates, on the other hand, directly with the exceedingly large pharynx or branchial chamber, which extends nearly to the hinder end of the body, and is perforated by a vast number of gill-openings, through which the water taken in at the mouth passes into the atrial chamber. Instead of passing directly into the latter chamber with the water, the food is caught up in a mass of slime, and carried round the base of the mouth-tube until it reaches the entrance to the œsophagus, which lies near the hinder end of the dorsal surface of the branchial chamber. Hence it passes into the stomach, and along the intestine, which forms a U-shaped curve turned away from the dorsal aspect, the vent opening on the same aspect into the atrial cavity below the exhalent orifice. With regard to the nervous and circulatory system, it will suffice to say that there is a large nerve-ganglion embedded in the tissue of the inner tunic and lying on the dorsal surface of the body between the inhalent and exhalent orifices; and true blood-vessels are wanting, the blood merely flowing through a series of spaces in the muscles and other tissues of the body and between the viscera, and the heart forming a dilated tube. Unlike the higher Chordates, all the ascidians are hermaphrodite; the reproductive organs frequently lying within the loop of the intestine, and discharging into the atrial cavity alongside of the vent. A remarkable physiological feature of the group is to be found in the periodical reversal of the action of the heart; the blood being driven for a certain time in one direction, after which the heart makes a short pause, and then propels it in an opposite course.

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[1] Strictly speaking, the term “individual” includes all the units produced by budding from a common stock, but it is more convenient to use it in the ordinary sense.

In addition to certain other structural features, into the consideration of which it would be impossible to enter in a work of the present nature, the essential resemblance between the adult sea-squirts and the lancelets is to be found in the possession by both of a pharynx perforated by a large number of gill-openings, which convert it into a branchial chamber, opening into an atrial cavity instead of directly to the exterior. Several of the differences between the two, such as the hermaphrodite reproduction and the bent intestine of the sea-squirts, are probably due to their sessile habits, since such features are characteristic of most fixed organisms. Other points of difference are to be found in the absence of segmentation and the want of a dorsal nerve-tube and notochord in the adult ascidian, although, as we shall see, a remnant of the latter exists in the tail during the larval condition.

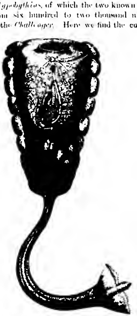
Development.

All ascidians, whether fixed or free in the adult condition, go through a free-swimming larval stage, during a part of which they develop a tail containing a notochord and nerve-tube; and as this feature is all important from a morphological point of view, it must be mentioned here, although necessarily in a very brief manner. Generally the larval condition lasts but a short time; and this may be the reason for the development of the tail, as a powerful swimming organ would seem to be essential in order to enable the creature to reach a spot suitable for its permanent existence. During its development a groove makes its appearance on one surface of the ascidian embryo, the large cells on the side of which grow inwards so as to enclose a tube, corresponding to the nerve-tube of Vertebrates, beneath which is the notochord. When of an oval shape, and while still contained in its investing membrane, the embryo assumes a ventral curvature, and at the same time produces a long tapering tail, which eventually becomes coiled round it. In addition to certain other structures, this outgrowing tail includes the nerve-tube and the notochord; and in some forms contains the only muscles developed at all. Subsequently a rudimentary brain, corresponding to a simple structure in the lancelet, makes its appearance; and likewise an unpaired eye, agreeing precisely in structure and mode of development with the rudimental median eye of the tuatera. After certain other changes, among which the development of a stomach and intestine are included, the larva is ready to burst from its membranes, which it does by spasmodic jerkings of the tail; and it thereupon starts on a free-swimming existence. Before long the cellular structure of the notochord in the tail begins to disappear by the formation of vacuities; and eventually the whole structure becomes filled with gelatinous matter. After a brief free existence it fixes itself by its muzzle to some submarine object with the tail stretched out and generally motionless. In a short time this appendage commences to shorten, and finally disappears by being drawn up into the body of the developing sea-squirt and absorbed. A further process of development results in the production of the perfect sea-squirt; but it

A CARTILAGINOUS FIXED SEA-SQUIRT, *Phallusia* (nat. size).

would be quite foreign to the scope of this work to enter into the details of the metamorphosis; and we may conclude this portion of our subject by stating that ascidians are probably the degenerate descendants of permanently free-swimming forms provided with a complete notochord and nerve-tube, both of which structures are now in most cases only temporarily retained in the tails of the larvæ.

Typical Ascidians. According to the classification adopted by Professor Herdman, the tunicates may be divided into three orders, the first of which is known as the Ascidiacea. This group includes both fixed and pelagic, simple and compound types, none of which are provided in the adult state with a tail and retain no trace of a notochord; the free-swimming forms constituting colonies, and the simple types being generally fixed. The outer tunic is permanent and well developed, generally increasing with the age of the individual, and the muscular structure of the inner tunic takes the form of an irregular network, and never of hoop-like bands. The walls of the large branchial chamber are perforated by numerous slits, opening into a single atrial cavity, which in turn communicates with the exterior by means of the exhalent aperture of the tunic, the vent opening into the atrial cavity. Many of the forms reproduce their kind by budding, and in most the sexually produced embryo develops into a tailed larva. The order is divided into three subordinal groups, of which the first—Ascidiæ Simplices—includes fixed (rarely unattached, but never free-swimming) and generally solitary forms, which very rarely reproduce by budding. When colonies occur, each of their individual members has a distinct outer tunic of its own, the whole society never being buried in a common investing mass. Four families are contained in this suborder, each represented by a large number of genera. Omitting mention of the first family, we may take as an example of the second (*Cynthiidæ*) the genus *Microcosmus*, of which specimens are shown in the figures on pp. 561, 562. As a family, these sea-squirts are characterised by being usually attached, and sometimes stalked, although rarely free. The outer tunic is generally membranous or leathery, but occasionally cartilaginous or covered with sand; while the inhalent aperture is usually, and the exhalent aperture invariably, provided with four lobes, meeting together at the centre. The branchial chamber is longitudinally folded, with its gill-slits straight; and the tentacles may be either single or compound. In the figured genus the body is attached and sessile, and the tunic, which is not incrusted with a continuous coat of sand, is thin, leathery, and tough; both its apertures having four lobes, and the tentacles being compound. As an example of the family *Ascidiidæ* we may take the well-known *Phallusia mammillata* from the seas of North-Western Europe and the Mediterranean, which is shown in the accompanying illustration, and is the sole representative of its genus. In the family to which it belongs, the body is attached and usually sessile, although rarely stalked; the inhalent aperture generally has eight, and the exhalent six lobes; and, as a rule, the outer tunic is either gelatinous or cartilaginous, although it may be horny. The branchial chamber is devoid of folds, with the gill-slits either straight or curved; and the tentacles are simple and thread-like. In the figured genus the body is erect and attached, and the outer tunic of a cartilaginous nature; its surface being mammillated in a very characteristic manner. It may be mentioned here that all the simple sea-squirts of this group, when touched, emit a jet of water; and that some of them, like the one figured on p. 561, are used as articles of food. To the same subfamily as *Phallusia* also belongs the extensive genus *Ascidia*, in which the outer tunic is soft and flexible, instead of being cartilaginous. A totally distinct subfamily is, however, indicated by the remarkable deep-sea genus *Hypobythius*, of which the two known species were obtained at depths varying from six hundred to two thousand nine hundred fathoms, during the voyage of the *Challenger*. Here we find the cup-shaped or pear-like body attached by a longer or shorter stem; while the apertures are circular and not closed by lobes. The outer tunic is cartilaginous, but soft and thin although thickened in places to form plates. The internal longitudinal bars usually found in the branchial chamber are wanting in this genus; the gill-slits are small and irregularly placed; and the viscera form a compact irregular mass on the dorsal side of this chamber. In the species here figured (*H. calycodes*), which is from the North Pacific, the stem is of great length, and the outer tunic thickened so as to form a number of nodules or plates; but in the South Atlantic form (*H.*



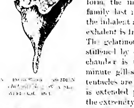
PEAR-SHAPED ASCIDIAN, *Hypobythius* (⅘ nat. size).

moseleyi) the stem is much shorter, and there is only a single plate, situated on the dorsal side. Of very large dimensions, these deep-sea ascidians are decidedly the most beautiful members of the class, and present some resemblance to the glass-sponges. A totally different type of structure is presented by the last family (*Clavelinidæ*) of the suborder, in which the body of each individual is attached by its posterior end, and usually by means of a stalk, to a creeping basal stolon, or common mass, from which young individuals are produced by budding. The outer tunic, which is usually thin and transparent, is in most cases gelatinous, although occasionally cartilaginous; and its circular apertures are but seldom distinctly lobed. Folds are wanting in the branchial chamber, but longitudinal bars may be present, although these lack the papillæ found in the preceding family; and the gill-slits are straight. The tentacles resemble those of the last family in their simple, thread-like form; but the digestive tract is usually extended behind the branchial chamber to form an abdomen. In addition to the ordinary sexual reproduction, colonies may be formed by budding from the common stolon. Ten genera are included in the family, from among which the typical *Clavelina* is selected for illustration. Here the body is elongated and club-shaped, but with no peduncle beyond the abdomen, and is attached to a delicate, branched creeping stolon, from which arise the buds. The thin outer tunic is gelatinous or cartilaginous, with its circular apertures devoid of lobes. The inner tunic is likewise thin, with its muscles mainly longitudinal; and the intestinal tract is extended to form a well-marked abdomen. In its restricted sense, the genus includes only half a dozen small species from North-Western Europe and the Mediterranean, the one here figured (*C. lepadiformis*) being characterised by the yellow or brown lines on the region known as the thorax.

A CREEPING ASCIDIAN, *Clavelina* (nat. size).

The second suborder of the typical sea-squirts—Ascidiæ Compositæ—includes fixed forms which reproduce by buds so as to constitute colonies in which the individuals are buried in a common investing mass, and thus possess no separate tunics. The group includes seven families, and Professor Herdman remarks that as many of these have originated independently from simple forms, the whole assemblage is to a certain extent an artificial one. In the first family (*Botryllidæ*) the colonies, as shown in the illustration on p. 568, usually form thin incrustations on seaweeds or stones, although they occasionally take the shape of thick fleshy masses; the individuals being arranged so as to form either circles or ellipses, or in branching lines. The common apertures of discharge are distinct, and usually furnished with lobes; the individual units are short, and show no division of the body into regions; and the outer tunic, which is usually soft, is traversed by numerous vessels with large terminal knobs. Internal longitudinal bars are present in the large and well-developed branchial chamber, in which the gill-slits are numerous; and the simple tentacles do not exceed sixteen in number. Budding may take place either from the sides of the units constituting the colony or from the vessels in the tunic. Among the five genera constituting the family, the typical *Botryllus* (figured on p. 572) has the colony thin and incrusting, with the individuals arranged in a circular manner, whereas in *Botrylloides* they form ellipses or branching lines. In the figured species of the latter (*B. albicans*), from North-Western Europe and the Mediterranean, the colony is pure white in colour, but in some it is purple with yellow or green markings, and in others yellowish green. As an example of forms in which the colony is thick and massive, we may cite the genus *Polycyclus*. Passing over the second family of the suborder, we come to the third (*Polyclinidæ*), in which the colony is usually massive, being sometimes incrusting, but in other cases lobed, or even stalked. The arrangement of the individuals is highly variable, and the common apertures of discharge are usually inconspicuous. Although of an elongated form, the individuals usually differ from those of the family last noticed by being divided into three regions; the inhalent aperture having six or eight lobes, while the exhalent is frequently provided with a tongue-like process. The gelatinous or cartilaginous outer tunic is frequently stiffened by embedded grains of sand; and the branchial chamber is usually small and poorly developed, with minute gill-slits and no internal longitudinal bars. The tentacles are small and not numerous; the digestive tract is extended posteriorly to a considerable distance beyond the extremity of the branchial chamber; and budding takes place from the end of the postabdominal region. The family is represented by well nigh a score of genera, among which *Amaroucium* may be selected as an example, on account of its numerous species. Here the colony is massive, being sometimes lobed or stalked; the mode of arrangement is usually compound and irregular; and the individuals are elongated, with six lobes to the inhalent orifice, and the postabdominal region elongated. The species here figured (*A. densum*) is from North-Western Europe, and is characterised by its greyish yellow colour, and the abundance of sand in the tunic; but other kinds may be black, orange, or rosy red, or white. In our figure *a* shows fully active individuals, while those in the outer ring indicated by *b* assume a kind of torpid condition during the winter, but give rise to fresh buds in the spring.

AN INCRUSTING ASCIDIAN (*[illegible]*) ON A SEA-WEED (nat. size).

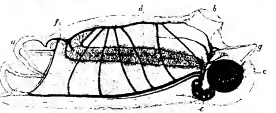


COMPOUND ASCIDIAN ([illegible]) IN WINTER CONDITION (nat. size).

Omitting mention of the remaining families of the group just considered, we come to the third and last suborder of the typical ascidians, namely, the phosphorescent ascidians.—A Lucie. These are represented solely by the genus *Pyrosoma*, which is thus the only member of the family *Pyrosomatidæ*. These ascidians are free-swimming pelagic forms, reproducing by buds in such a manner as to form colonies in the shape of a sac, such colonies sometimes attaining large dimensions. In the sack thus formed the constituent individuals are embedded in such a manner that all their inhalent apertures open on its outer surface, while their exhalent orifices are situated within the cylinder, the mouth of the sac forming the common discharging aperture. The apertures of the units are not lobed, and the outer tunic is gelatinous and transparent, containing no hard spicules, but provided with numerous minute cells. The branchial chamber is well-developed, and the tentacles are simple. The first four individuals of the colony grow in the form of buds from a rudimentary sexually-developed larva; the subsequent increase taking place by budding from a ventral posterior stolon. The genus is represented only by four species, in one of which (*P. elegans*) the individuals form regular oblique rows in the walls of the sac, while in the other three they are arranged irregularly. The largest of all is *P. spinosum*, from the Atlantic, in which the total length of the colony may be upwards of four feet, this species being distinguished by the surface of the sac being provided only with short sharp spines, instead of with large processes of the tunic. It is to these ascidians that the most beautiful phosphorescence of tropical seas is due, each colony, when stimulated by a touch or shake of the water, giving forth a brilliant ball of bluish light, which lasts for several seconds, as the organism floats along beneath the surface, and then suddenly disappears. A colony is figured on p. 576.

Describing the luminosity produced by these ascidians, Bennett states that on one occasion in the Australian seas, when he reached the deck, he observed a broad and extensive sheet of phosphorescence, extending in a direction from east to west, as far as the eye could reach. The luminosity was confined to the range of animals in this shoal, for there was no similar light in any other direction. I immediately cast the towing-net over the stern of the ship, as we approached nearer the luminous streak, to ascertain the cause of this extraordinary and so limited phenomenon. The ship soon cleaved through the brilliant mass, from which by the disturbance, strong flashes of light were emitted; and the shoal, judging from the time the vessel took in passing through the mass, may have been a mile in breadth. The passage of the vessel through them increased the light around to a far stronger degree, illuminating the ship. On taking in the towing-net, it was found half filled with *Pyrosoma*, which shone with a pale, greenish light; and there were also a few shell-fish in the net at the same time. After the mass had been passed through, the light was still seen astern, until it became invisible in the distance." Frequently the phosphorescence is intermittent, periods of luminosity alternating with intervals of darkness. Moseley writes that during the voyage of the *Challenger*, "a giant *Pyrosoma* was caught by us in the deep-sea trawl. It was like a great sac, with its walls of jelly about an inch in thickness. It was 4 feet in length, and 10 inches in diameter. When a *Pyrosoma* is stimulated by having its surface touched, the phosphorescent light breaks out at first at the point stimulated, and then spreads over the surface of the colony as the stimulus is transmitted to the surrounding animals. I wrote my name with my finger on the surface of the giant *Pyrosoma*, as it lay on deck in a tub at night, and my name came out in a few seconds in letters of fire.'

Non-Luminous Pelagic Ascidians. With the exception of the family just mentioned, and also of a second one which constitutes the third order, the present ordinal group—termed the Thaliacea—includes the whole of the free-swimming pelagic representatives of the class. Either simple or compound in structure, these ascidians lack both a tail and a notochord in the adult, but have a persistent outer tunic, which may be either feebly or fully developed. In the inner tunic the muscles are arranged in the form of more or less nearly complete circular bands, the contraction of which forms the motive agency of the creatures. The branchial chamber has either two large openings, or a number of smaller gill-slits, leading to a single atrial cavity; the latter communicating with the exterior by the exhalent aperture, and the vent opening within it. In all the members of the group an alternation of generations takes place; and this may be further complicated by the individuals of a single generation being unlike one another. During one period of existence temporary colonies may be formed, but these never increase by the budding of the constituent units, which eventually separate from one another and disperse.



AN INDIVIDUAL OF A CHAIN-SALPA.

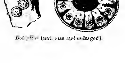
a, inhalent, and b, exhalent orifice; d, gill; c, c, viscera; f, eye; g, pedicle of union. (nat. size.)

The well-known salpæ form a suborder—Hemimyaria—characterised by the formation of temporary colonies in the sexual generation, and represent a family (*Salpidæ*) distinguished by the muscular bands of the inner tunic being incomplete on the lower surface of the body. Pelagic in habit, and transparent in structure, salpæ have been not inaptly compared to a barrel with both ends knocked out, and really consist of little more than a huge pharynx, swimming through the water, and taking in huge mouthfuls of the same at each contraction of its muscles. Through the hollow, to below the hinder aperture, runs obliquely a rod-like gill (*d*) from above the mouth, although this is too narrow to interfere with the free flow of the water; while the lower surface of the interior of the creature is furnished with a ciliated slime-secreting band, corresponding to the structure known in other ascidians and the lancelet as the endostyle. It may here be well to mention that in the lancelet the structure in question is an elongated gland situated at the base of the pharynx, and against which the ends of the gill-bars abut. The only part of the salpa that is not transparent is the thick mass of viscera (*e, e*) at the hinder end of the body; while the muscular bands by the contraction of which the water is driven through the barrel, may be compared to the hoops of the latter. Externally the whole animal is invested with a thick, tough, transparent tunic; and in some forms there are two tail-like appendages to the hinder end of the body. Such is the structure of a salpa; but there are two generations in the life of these creatures, namely, the simple form and the chain-like or aggregate form; the first being shown in the upper, and the second in the lower figure of the Plate facing p. 561. It will be observed that in the chain the individuals are attached to one another by their upper and lower surfaces, and thus have their two apertures free; and when taken from the water the whole chain, which is several feet in length, can be easily resolved into its component units. The specimen represented in the annexed figure is one of these detached units from a chain, the projection marked *g* being for the purpose of attachment to the neighbouring individual. Although extremely interesting and curious, the whole history of the development of salpæ is so complicated that it is almost impossible to explain it fully in a popular work. It may be stated, however, that the solitary salpa is born from an egg carried within the body of one unit of the aggregate form, the embryo being nourished by means of a placenta from the blood of the parent. On the other hand the chain-salpæ are produced asexually by budding from a stolon within the body of the solitary form. In the chain-salpa the eggs arise, however, at an exceedingly early period of its development, with the curious result that three generations are present at one time in a single individual. Thus a solitary salpa has within it the buds of an aggregate salpa, the units of which may each contain eggs which will ultimately develop into the next solitary form. And, as a matter of fact, in a solitary salpa the germ-cells of the embryo of the next solitary form are actually visible before the development of the stolon which is to give rise to the chain-form. As the stolon forms in the body of the latter, it includes within it the mass of germinal cells; and while the former elongates to form the chain of units, the mass of germ-cells likewise lengthens, with the result that a single egg-cell is shut off in each unit of the chain. Simple salpæ vary in size from a quarter of an inch to upwards of eight inches; and in some parts of the ocean-surface are met with in [illegible] swarms. Although more abundant in tropical than in the cooler seas, their northward range extends beyond Scotland and Norway, while to the south they have been taken below the latitude of Cape Horn and the most southern point of Australia. Dr. Brooks writes that "they are abundant only after the water has been for some time undisturbed by winds, and as prolonged calms are more frequent in warm seas, those waters are most favourable for the development of these animals, which multiply with most astonishing rapidity. The smaller species are often so abundant that for hundreds of miles any bucketful of water dipped up at random, will be found to contain hundreds of them. In such places collecting with the surface-net becomes impracticable, for almost as soon as the net is dipped into the water, it becomes choked with a mass so dense that nothing can enter it." The food of these creatures consists of minute marine organisms, both animal and vegetable. In swimming, chain-salpæ progress by an undulating snake-like movement. Usually the family is divided into the two genera *Salpa* and *Cyclosalpa*, the latter being distinguished by having the digestive tract coiled up; but some writers have divided the first of these two into several subgeneric groups. A second family is represented by the very imperfectly known genus *Octacnemus*, dredged at depths of between one and two thousand fathoms in the South Pacific, the body being much flattened, and probably attached by one extremity. Nothing is known as to the life-history of this singular form.

The second suborder—Cyclomyaria—of the free-swimming non-luminous ascidians takes its name from the muscular bands of the inner tunic forming perfect rings, and is typically represented by the genus *Doliolum*. The life-history is complicated by polymorphism; the tailed larva developing into a sexless form, the buds from which give rise to nutritive units, fostering units, and reproductive units. In the typical genus all the muscles form encircling hoops, and the three forms of the sexual generation occur together on one stolon, or outgrowth; but in *Anchinia* there are only two complete muscular rings, and the three forms of the sexual generation are produced successively.

Tailed Ascidians

The free-swimming form known as *Appendicularia* is the type of the third and last order—Larvacea—of the class, all the members of which are characterised by the possession in the adult state of large tail-like appendages, furnished with a skeletal axis. These creatures, which are of minute size, have not undergone the degeneration so noticeable in the adult of the other tunicates, and thus correspond much more closely to the larval stage of the latter. A curious feature is the rapid production of a temporary outer tunic, which may be shed at any time, and replaced by a second one. There is no separate atrial cavity; and the branchial chamber is simply an elongated pharynx, with two openings on the lower surface, which correspond to the gill-slits, and are well furnished with cilia. The nervous system consists of a large ganglion placed in the anterior part of the dorsal surface, followed by a long chord provided with smaller ganglia, and extending backwards over the intestine to reach the tail, where it runs along the left side of the skeletal axis. The intestine itself is situated behind the branchial chamber, and the vent opens on the inferior or ventral aspect of the body in advance of the gill-slits. Neither budding, metamorphosis nor alternation of generations takes place; and the reproductive organs are situated at the hinder end of the body. The group comprises only the single family *Appendiculariidæ*, which contains five genera the names and characters of which it will be unnecessary to mention.

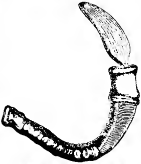


Botryllus (nat. size and enlarged).

CHAPTER V.

THE WORM-LIKE PROTOCHORDATES.—Class **Enteropneusta.**

Balanoglossus THE last, and at the same time the lowest, group of the Protochordates is typically represented by the marine *Balanoglossus*. Living buried in the sand or mud of the seashore, these worm-like creatures exhale a peculiar odour resembling that of the chemical substance termed iodoform, and secrete a copious supply of slime, to which adhere particles of sand, thus forming a protective tube for their bodies. At the front extremity of the creature, writes Mr. Willey, "there is a long and extremely sensitive proboscis, which is capable of great contraction and extension, and is in the living animal of a brilliant yellow or orange colour. Behind the proboscis follows a well-marked collar-region, consisting externally of a collar-like expansion of the integument, with free anterior and posterior margins overlapping the base of the proboscis in front and the anterior portion of the gill-slits behind. (The gill-slits are seen in our illustration below the collar.) In the ventral middle line, at the base of the proboscis, and concealed by the collar, is situated the mouth. Following behind the collar is the region of the trunk or body proper, which, in the adult of some species, reaches a relatively enormous length, even extending to 2 or 3 feet. The ectodermal covering of the body consists in general of ciliated cells, among which are scattered unicellular mucous glands; the cilia, however, appear to be more prominent on the proboscis than elsewhere. In the region of the trunk, which immediately follows upon the collar-region, there are a great number of paired openings on the dorsal side of the body, placing the anterior portion of the digestive tract in communication with the outer world. These are the gill-slits, and they are arranged strictly in consecutive pairs to the number of upwards of fifty in the adult. In their structure, and more especially in the possession of tongue-bars, they bear a remarkable resemblance to the gill-slits of the lancelet. This is particularly striking in young individuals. As the adult form is approached in the development, the bulk of the gill-slits sinks below the

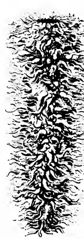

A YOUNG BALANOGLOSSUS (much enlarged).

surface, only opening at the latter by small slit-like pores, and thus their true character is obscured in superficial view. On dissection, a rod-like structure, which arises as an outgrowth of the alimentary canal above the mouth, is seen projecting into the interior of the proboscis; and this rod has been identified with the vertebrate notochord. Above this rod, and extending farther back, is a dorsal nerve-chord, corresponding to the vertebrate nerve-tube, and having, as in the latter, a central canal, at least during the earlier stages of growth. Some distance behind the notochord this nerve-tube gives off a descending branch connecting it with a similar chord lying on the ventral aspect of the animal.

We thus have evidence of the existence in this strange worm-like creature of three essentially vertebrate characteristics, namely, gill-slits, a notochord, and a nerve-tube; and it is not a little remarkable that while in the sea-squirts the notochord is found in the transitory tail, in *Balanoglossus* it is situated in the anterior extremity, where it extends some distance in advance of the mouth. Quite recently it has been shown that the tornaria-larva of one species of *Balanoglossus* also possesses an endostyle (see p. 570) comparable to that of the lancelet and sea-squirts. That the creature under consideration is closely allied to the other Protochordates and thus to the Vertebrates may be considered fairly certain; but there are also indications of affinity with Nonchordates. In the first place, while certain species of *Balanoglossus* pass through the earlier stages of their existence without undergoing a metamorphosis, in other kinds such a transformation takes place; the young making its first appearance in the world in the form of what is known as a tornaria-larva, or one closely resembling that of a starfish. And it is held by competent naturalists that this resemblance must be indicative of some kind of genetic relationship between *Balanoglossus* on the one hand and starfish and sea-urchins on the other. In the second place, there are not wanting indications of affinity with the so-called Nemertine worms, described in the next volume; these resemblances presenting themselves in the structure of the outer layer of the skin, the presence of a proboscis (kept retracted in the Nemertines), as well as in regard to the nervous system, the reproductive organs, and the alimentary canal.

Other Forms The two other forms included among the Protochordates are respectively known as *Cephalodiscus* and *Rhabdopleura*, and bear the same relation to the last as is presented by the compound ascidians to the lancelet. Both these curious creatures are fixed forms living in societies, reproducing their kind by means of buds, and having a U-shaped, instead of a straight, intestine. Both are likewise deep-water creatures, the former having been dredged in the Straits of Magellan at a depth of two hundred and forty-five fathoms, while the latter has been taken off the Shetlands in ninety, and off the Lofoten Islands in two hundred fathoms. Extremely minute in size, *Cephalodiscus* lives in colonies, the individuals wandering about the tubes of a common house, the walls of which are composed of a gelatinous material, covered with spiny projections, and perforated by numerous apertures for the free circulation of water. The mouth is overhung by a large shield-like plate, surmounted by the row of plume-like tentacles; while on the side of the body is a pedicle from which grow the buds; locomotion being probably effected by means of this pedicle and the mouth-plate. The latter contains a short notochordal rod; and there is a single pair of gill-slits opening from the pharynx, water being passed into this from the mouth by the action of the tentacles. In the allied genus *Rhabdopleura* the individuals which go to form a colony are connected with one another by means of a common stem, representing the remnants of their original contractile stalks; this stem gradually drying up with the growth of the colony in the region most remote from the living polyps. Each polyp has but a single plume-like tentacle; and the buds arising from the soft part of the common stem never become detached. While the nervous system and notochord are essentially the same as in *Cephalodiscus*, gill-slits are wanting.

Ancestry of Chordates. Before making a few brief remarks on this interesting but perplexing subject, it may be mentioned that while we have no satisfactory clue as to the first origin of the notochord, it has been suggested that the original function of gill-slits was to carry off the superfluous water entering the mouth with the food, the connection with respiration being a later addition to these structures. It is also an important factor in the consideration of this subject to bear in mind that the whole of the existing Protochordates are to a greater or less extent degenerate types, although they doubtless retain some original and simple primitive features. For the proud position of the original ancestral stock, from which have sprung both Protochordates and Vertebrates, there are many claimants; among these being segmented worms or annelids, creatures allied to the existing king-crab, and star-fishes and sea-urchins. With regard to the annelid theory, Mr. Willey very significantly remarks that in this case the doctrine of parallelism in development has not been sufficiently taken into account; and that the more complete the superficial resemblance between an Annelid and a Vertebrate, in the same measure is the parallelism in their developmental history the more striking and their genetic affinity the more remote. Neither is it likely that the king-crab line of descent (in spite of the apparent identity in the structure of one layer of its shell with that of the Cephalaspidians) will hold good. The evidence in favour of an alliance between Vertebrates and Echinoderms (sea-urchins and star-fishes), through the intervention of *Balanoglossus*, seems, however, to be steadily gaining ground. Mr. Willey, for instance, remarks that while it is probable that the proximate ancestor of the Vertebrates was a free-swimming creature, intermediate in structure between an ascidian larva and the lancelet, the ultimate or primordial ancestor may be assumed to have been a worm-like animal with an organisation approximately on a level with that of the bilaterally symmetrical progenitors of the Echinoderms. Mr. Garstang also having proved that the larvæ of the whole of the latter group can be derived from a single common type, and likewise having shown that the tornaria-larva of *Balanoglossus* can be referred to the same modification, expressed an opinion that the Vertebrates also trace their origin to the same free-swimming pelagic form. Perhaps still more probability may attach to a later theory of the same observer, who now comes to the conclusion that Echinoderms, Enteropneusta and Chordates are all divergent branches from a common unknown ancestor; such ancestor being a bilaterally symmetrical creature with the general appearance of a certain type (*Auricularia*) rm larva. From the hypothetical common stock the Echinoderms appear to have been derived by a series of changes mainly correlated with the assumption of their characteristic radial symmetry; while the Chordates retained the original bilateral symmetry, at the same time undergoing certain changes, into the consideration of which it will be unnecessary to enter in this place. Still more complicated are the changes necessary to evolve *Balanoglossus* and its allies from the ancestral form. Such of our readers as are desirous of pursuing further this interesting subject, may be referred to the works of the observer last mentioned.



A PYROSOMA COLONY

In life the colony assumes a horizontal position

INDEX.

VOL. V.

Ablepharus, 168
Abramis, 463.
Acanthoclinidæ, 395.
Acanthoclinus, 395.
Acanthias, 534.
Acanthodactylus, 166.
Acanthodes, 548.
Acanthodii, 315, 547.
Acanus, 340
Acerina, 337.
Acichelyidæ, 86.
Acipenser, 514.
Acipenseridæ, 514.
Acris, 279.
Acrochordus, 198.
Acrodus, 532
Acronuridæ, 362.
Acronurus, 363
Actinistia, 518
Actinopterygii, 315, 384.
Adders, 220.
  Banded, 221.
  Death, 225.
  Puff, 235.
  Resplendent, 220.
Æthrospondyli, 506.
Aetobatis, 544.
Agama, 120.
Agamas, 120.
  Armed, 120
  Rough-Tailed, 122.
  Spinose, 121.
Agamidæ, 117.
Aglypha, 198.
Agonus, 384.
Alburnus, 466.
Alepocephalidæ, 491.
Alepocephalus, 491.
Alligator, 18.
Alligators, 18.
  Double-Tusked, 20.
Alligator-Terrapin, 79.
Alopecias, 526.
Alytes, 285
Amaroucium, 568.
Amblycephalidæ, 229.
Amblyopsidæ, 471.
Amblyopsis, 471
Amblyrhynchus, 136.
Amblystoma, 292.
Ameiva, 156.
Amia, 508.
Amiidæ, 508.
Ammocœtes, 552
Ammodytes, 438

Amphibians, 257
Amphichelydia, 98
Amphicyon, 198, 202.
Amphignathodontidæ, 286.
Amphioxus, 558.
Amphipnous, 459
Amphisbæna, 158
Amphisbænidæ, 156.
Amphisile, 406
Amphiuma, 305.
Amphiumidæ, 302
Anabantidæ, 409.
Anabas, 410.
Anableps, 470.
Anacanthini, 430.
Anacanthus, 427.
Anaconda, 189
Anarrhichas, 394.
Anchinia, 572.
Anchovy, 491.
Ancistrodon, 213.
Anelytropidæ, 171
Angel Fish, 535
Anglers, 378
Anguidæ, 145.
Anguilla, 446
Anguis, 147.
Anolis, 130.
Anomalochilus, 196.
Anomodonts, 254
Anoplogaster, 355
Antennarius, 380.
Anthias, 339.
Aphanius, 487.
Apionichthys, 444.
Apoda, 309.
Aporoscelis, 127.
Appendicularia, 572.
Arapaimas, 477.
Arius, 454.
Armed Bull-Head, 384.
Arthrodira, 315, 330.
Ascidia, 566.
Ascidians, 561
Ascidiidæ, 565
Asp, 236.
Aspidites, 186.
Aspidorhynchidæ, 507.
Aspidorhynchus, 507.
Aspius, 464.
Aspro, 336.
Asteracanthus, 532.
Astronesthes, 483.
Atherina, 397.
Atherinidæ, 397.

Atlantosaurus, 35.
Auliscops, 406.
Aulostoma, 406.
Aulostomatidæ, 403.
Australian Lung-Fish, 326.
Axolotls, 299

Badis, 352.
Bæna, 98.
Bagarius, 451.
Bagrus, 456.
Balistes, 427
Balistidæ, 427.
Balanoglossus, 573.
Band-Fishes, 391.
Baptemys, 78.
Barbel, 458.
Barbus, 458.
Barracuda Pike, 397.
Barracudas, 362, 397.
Barramundi, 326.
Basiliscus, 132.
Basilisks, 132.
Bass, 339.
Batagur, 75.
Bathydraco, 375
Bathythrissidæ, 485.
Batrachidæ, 376
Batrachopsis, 284
Batrachus, 377.
Batrachyperus, 302.
Bdellostoma, 554
Beaked Fish, 471
Beaked Gurnards, 385
Beaked Lizards, 252.
Beaked Salmon, 481.
Bellia, 72
Belone, 400.
Belonorhynchus, 517.
Berry-Bone Fishes, 330.
Berycidæ, 353.
Beryx, 354, 355.
Betta, 413.
Bichir, 517.
Bitterling, 462.
Bleak, 465.
Blennies, 391, 393
Blenniidæ, 391, 393.
Blennius, 394
Blind-Fish, 471
Blind-Soles, 444.
Blind-Worm, 147
Blue Shark, 522, 523.
Boa, 191.
Boidæ, 181.

Boidæ, 186.
Boas, 187.
    Dog-Headed, 189.
    Keeled, 189.
    Tree, 181.
    True, 191.
Bolyeria, 190.
Bombinator, 281.
Bony Fishes, 337.
Bony Pike, 306, 307.
Bow Fin, 308.
[illegible], 307.
[illegible], 308.
[illegible], 308.
Brama, 347.
[illegible], 431.
Branchiosaurus, 119.
Branchiostoma, 568.
Branchiostomatidæ, 568.
Bream, 465.
Brevirostres, 35.
Brookesia, 172.
Brosmius, 437.
Brotula, 431.
Bufo, 277.
Bufonidæ, 276.
Bull-Heads, 380, 381.
Bungarus, 221.
Burbot, 436.
Bushmaster, 244.

Cachuga, 71.
Caimans, 29.
Caiman, 27.
Calabaria, 189.
Calamoichthys, 327.
Californian Toad, 112.
Callagur, 75.
Callichthys, 456.
Callionymus, 491.
Callorhynchus, 332.
Callophis, 229.
Calotes, 149.
Cantharus, 347.
Cantoria, 218.
Carangidæ, 363.
Caranx, 362, 361.
Carassius, 458.
Carcharias, 522, 524.
Carchariidæ, 524.
Carcharodon, 528.
[illegible]
Carettochelys, 97.
Carps, 456.
    Bearded, 462.
    Crucian, 458.
    Golden, 458.
    True, 456.
Casarea, 193.
Cat-Fishes, 452.
    Eel-Like, 454.
    Electric, 455.
    Mailed, 456.
    [illegible], 454.
Catostomus, 459.
Caudisona, 250.
Cave Fish, 437.
Centrarchidæ, 358.
Centrarchus, 358.
Centrolenidæ, 108.
[illegible], 104.
Centrolophus, 358.
Centrophorus, 531.
Centropristis, 349.
Cephalaspis, 550.
Cephalochorda, 571.
Cephaloptera, 541.
Cepola, 381.
Cepolidæ, 391.
Cerastes, 236.
[illegible], 313.
Ceratobatrachidæ, 273.
Ceratobatrachus, 273.
Ceratodus, 326.
Ceratophrys, 274.
Ceratops, 39.
Cestracion, 530.
Cestraciontidæ, 530.
[illegible], 527.
Chætodon, 343.
Chætodontidæ, 343.
Chalcides, 170.
Chamæleon, 172.
Chameleons, 171.
Chamæleontidæ, 172.
Chamæsaura, 144.
Channa, 408.
Channidæ, 408.
Characinus, 468.
Charina, 195.
Char, 561.
Chauliodus, 483.
Chelmo, 343.
Chelodina, 93.
Chelone, 82.
Chelonia, 12.
Chelonidæ, 81.
Chelydra, 79.
Chelydridæ, 78.
Chelyidæ, 88.
Chelys, 90.
Chersydrus, 199.
Chilodactylus, 353.
Chiloscyllium, 530.
Chimæra, 331.
Chimæridæ, 331.
Chimæroids, 315, 331.
Chioglossa, 291.
Chiridæ, 392.
Chirocentridæ, 481.
Chirocentrus, 481.
Chirotes, 157.
Chirus, 392.
Chisel-Jaw, 480.
Chitra, 100.
Chlamydosaurus, 123.
Chlamydoselache, 552.
Chologaster, 172.
Chondropython, 186.
Chondrostei, 510.
Chondrosteus, 516.
Chondrostoma, 462.
[illegible], 351.
Chorinemus, 350.
Chromididæ, 418, 422.
Chromis, 423.
Chrysemys, 73.
Chrysichthys, 455.
Chthonerpeton, 310.
Chub, 459.
[illegible], 397.
Cladodus, 546.
Cladoselache, 547.
[illegible], 38.
Clarias, 454.
Claudius, 78.
Clavelina, 567.
Clavellinidæ, 567.
Clemmys, 70.
Clidastes, 249.
Climbing Perch, 410.
Clupea, 486.
Clupeidæ, 486.
Cnemidosaurus, 102.
Cinosternidæ, 77.
Cinosternum, 77.
Cinixys, 63.
Cirrhites, 350.
Cirrhitichthys, 350.
Cirrhitidæ, 349.
Cistudo, 66.
Coal Fish, 434.
Cobitis, 467.
Cobras, 222.
Coccosteidæ, 331.
Coccosteus, 330.
Cod Tribe, 431.
Cœcilia, 310.
Cœciliidæ, 309.
Cœlacanthus, 518.
Coffer Fishes, 427, 428.
Coilia, 491.
Coluber, 209.
Colubridæ, 198.
Comb-Gilled Fishes, 423, 427.
Comephorus, 396.
Compsognathus, 36.
Conger, 449.
Conolophus, 137.
Congrogadus, 439.
Corallus, 189.
Coronella, 205, 209.
Coryphæna, 368.
Coryphænidæ, 368.
Corythophanes, 134.
Cottidæ, 386.
Cottus, 381.
Craits, 221.
Crenidens, 347.
Crocodiles, 10.
    Earlier, 32.
    Estuarine, 22.
    Existing, 15.
    Indian, 21.
    Long-Nosed, 27.
    Nile, 24.
    Orinoco, 27.
    Sharp-Nosed, 26.
    Siam, 25.
    Stumpy, 20.
    True, 21.
Crocodilia, 10.
Crocodilidæ, 15.
Crocodilus, 21.
Crossopterygii, 315, 333, 517.
Crotalus, 259.
Cryptobranchus, 304.
Cryptodira, 89.
Ctenosaura, 141.
Curtidæ, 355.
Curtus, 355.
Cybium, 371.
Cyclanorbis, 100.
Cyclemys, 66.
Cycloderma, 100.
Cyclomyaria, 572.

- *Cyclopteridæ*, 386.
- *Cyclopterus*, 387.
- *Cyclosalpa*, 572.
- *Cyclostomata*, 549.
- *Cyclura*, 140.
- *Cynodon*, 469.
- *Cynthiidæ*, 565.
- *Cyprinidæ*, 456.
- *Cyprinodon*, 470.
- *Cyprinodontidæ*, 469.
- *Cyprinus*, 456.
- *Cyttidæ*, 366.
- *Cyttus*, 367.

- *Dactylopteridæ*, 384.
- *Dactylopterus*, 385.
- Dace, 460.
- *Damonia*, 72.
- Danubian Perches, 336.
- *Dapedius*, 510.
- *Dapedoglossus*, 477.
- *Dasypeltis*, 214.
- *Dendrelaphis*, 214.
- *Dendrobates*, 271.
- *Dendrobatidæ*, 271.
- *Dendrophis*, 214.
- *Dendrophryniscidæ*, 276.
- Dentice, 348.
- *Dermatemydidæ*, 77.
- *Dermatemys*, 78.
- *Desmognathus*, 302.
- Devil-Fish, 543.
- *Dibamidæ*, 171.
- *Dicamptodon*, 302.
- *Dicerobatis*, 544.
- Dicynodonts, 255.
- *Dinosauria*, 33.
- Dinosaurs, 33.
  - Armoured, 38.
  - Bird Like Group, 36.
  - Carnivorous Group, 35.
  - Horned, 38.
  - Lizard-Footed Group, 34.
- *Diodon*, 429.
- *Diodontidæ*, 428.
- *Dipnoi*, 315, 326.
- *Diplacanthus*, 548.
- *Diplocynodon*, 20.
- *Diplomystus*, 490.
- *Dipsas*, 217.
- *Discoglossidæ* 281.
- *Discoglossus*, 284.
- *Distira*, 229.
- *Ditrema*, 422.
- *Ditrematidæ*, 421.
- Dog-Fishes, 529, 530.
  - Spiny, 533.
- *Dolichosauria*, 249.
- *Dolichosoma*, 318.
- *Doliolum*, 572.
- Dorab, 484.
- *Doras*, 455.
- Dories, 366.
- *Doryichthys*, 425.
- Double-Eyes, 470.
- *Draco*, 118
- Dragonets, 391.
- Dragon-Fish, 386.
- Drum, 356.
- *Dryophis*, 217.

- Eagle-Rays, 543.
- *Ecaudata*, 257
- *Echeneis*, 371.
- *Echiostoma*, 483.
- *Echis*, 238.
- *Edaphodon*, 332.
- Eel-Pout, 435.
- Eels, 445.
  - Conger, 449.
  - Deep-Sea, 449
  - Electric, 451
  - Serpent, 449.
  - Short-Tailed, 450.
  - Single-Slit, 450
  - Spiny, 395.
  - True, 446.
- Eja, 237.
- *Elacate*, 371.
- *Elaps*, 218.
- *Elasmobranchii*, 315.
- *Elasmodus*, 332
- Electric Eel, 451.
- Electric Rays, 542.
- *Elops*, 491.
- *Elseya*, 93.
- Emperor-Fish, 341.
- *Emyda*, 100.
- *Emydura*, 93.
- *Emys*, 68.
- *Encheliophis*, 438.
- *Engraulis*, 491
- *Engystoma*, 271
- *Engystomatidæ*, 271.
- *Enteropneusta*, 573.
- *Enygrus*, 189.
- *Eosphargis*, 88.
- *Epicrates*, 188.
- *Erythrinidæ*, 468.
- *Eryx*, 194.
- Escuerzos, 275.
- *Esocidæ*, 473.
- *Esox*, 473.
- *Eublepharis*, 116.
- *Eumeces*, 131
- *Eustomias*, 484.
- *Exomegas*, 558.

- Fan-Finned Fishes, 334.
- Feather-Backs, 475.
- Fer de Lance, 248.
- Ferreiro, 281.
- *Fierasfer*, 438.
- Fighting-Fish, 413.
- File-Fishes, 427.
- Firm-Fin, 350.
- Fishes, 314.
- Fish Lizards, 250.
- *Fistularia*, 406.
- Flat-Fishes, 439.
- Flounder, 448.
- Flute-Mouths, 403, 405.
- Flying-Dragons, 39.
- Flying-Fish, 400, 401.
- Flying-Gurnards, 384
- Fold-Finned Sharks, 546.
- Fringe-Finned Ganoids, 517.
- Frog-Fishes, 376, 377.
- Frogs, 257, 265.
  - Agile, 266.
  - Antillian, 276.
  - Bull, 268.
  - Common, 266.
  - Darwin's, 272.
- Frogs—*continued*.
  - Disc-Tongued, 284.
  - Edible, 266.
  - European, 266.
  - Extinct, 284.
  - Fire Bellied, 284.
  - Flying, 269.
  - Grasshopper, 279.
  - Guppy's, 268
  - Horned, 274.
  - Leaf, 276.
  - Midwife, 285.
  - Montezuma's, 268
  - Moor, 266.
  - Narrow-Mouthed, 271.
  - Piping, 276.
  - Pouched, 282.
  - Sharp-Nosed, 273.
  - Short-Headed, 272
  - Southern, 273.
  - Spur-Toed, 286.
  - Tongueless, 286.
  - Tree, 271, 279.
  - Typical, 265
  - Water, 265.

- *Gadidæ*, 431.
- *Gadus*, 433.
- Galesaur, 255.
- *Galeus*, 524.
- Gavial, 30.
  - Extinct, 31.
  - Schlegel's, 29.
- *Gavialis*, 30
- Gar-Pike, 400.
- *Gastrochisma*, 369.
- *Gastrosteidæ*, 403.
- *Gastrosteus*, 403.
- *Geckonidæ*, 110.
- Geckos, 110.
  - Eyelid, 116.
  - Fringed, 114.
  - Lobe-Footed, 112.
  - Turkish, 112.
  - Wall, 111.
- *Gegenophis*, 310
- *Genypterus*, 438.
- *Geoëmyda*, 64.
- *Geotria*, 553.
- *Gerrhonotus*, 146.
- Gilt-Heads, 348
- *Glauconia*, 180.
- *Glauconiidæ*, 180.
- Globe-Fishes, 428.
- Gobies, 388.
- *Gobiidæ*, 388.
- *Gobio*, 459.
- *Gobius*, 388.
- *Gobiesocidæ*, 407.
- *Gobiesox*, 408.
- *Gongylophis*, 195.
- *Goniognathus*, 369.
- *Goniopholis*, 32.
- *Gonorhynchidæ*, 481.
- *Gonorhynchus*, 481.
- Grayling, 505.
- Grey Mullets, 399.
- Gudgeons, 459.
- Gurami, 412.
- Gurnards, 380, 382.
- *Gymnarchus*, 475
- *Gymnelis*, 431.

Gymnoscopelus, 482.
Gymnotidæ, 445.
Gymnotus, 451.
Gymnoptychus, 519.

Haddock, 438.
Hag-Fishes, 550, 553.
Hair-Tails, 362.
Hairy-Backs, 392.
Hake, 435.
Halargyreus, 435.
Half Beaks, 401.
Haliophis, 439.
Hamadryad, 223.
Hammer Headed Shark, 524
Haplochiton, 492.
Haplochitonidæ, 491.
Haplodactylus, 347.
Hardella, 75.
Harriotta, 332.
Hausen, 515.
Hedgehog Mouths, 488.
Helicops, 204.
Hell-Bender, 304.
Helminthophis, 180.
Heloderma, 148.
Helodermatidæ, 148.
Hemerocoetes, 392.
Hemibungarus, 221.
Hemichelys, 97.
Hemimyaria, 570.
Hemiphractidæ, 286.
Hemirhamphus, 401.
Hemirhynchus, 362.
Heniochus, 344.
Herrings, 486, 487, 490.
Heterocarpus, 422
Heterocephalus, 239.
Heterotis, 478.
Hippocampus, 426.
Hippoglossus, 442.
Histiophorus, 358.
Holacanthus, 344
Holocentrum, 354
Holocephali, 315, 326, 331.
Holoptychius, 519.
Holibut, 442.
Homalopsis, 218
Homalopterus, 456
Homœosaurus, 254.
Homopus, 82.
Hoplognathidæ, 349.
Hoplognathus, 349.
Hoplosaurus, 35.
Horned Lizards, 142.
Horse-Mackerels, 363.
Hybodus, 532.
Hydraspis, 93.
Hydrocyon, 469.
Hydromedusa, 92.
Hydrophis, 228.
Hydrus, 228.
Hylæobatrachus, 300.
Hylæochelys, 97.
Hylidæ, 279.
Hyla, 280.
Hylodes, 276.
Hylonomus, 313.
Hynobius, 302.
Hyodon, 479.
Hyodontidæ, 479
Hyperodapedon, 254.
Hypobythius, 566
Ichthyophis, 310.
Ichthyopterygia, 250.
Ichthyosaurs, 250.
Ichthyoscopus, 375
Ichthyotomi, 315, 545.
Ide, 460.
Iguana, 139.
Iguanas, 128.
  Black, 141.
  Extinct, 142.
  Fijian, 140.
  Ring-Tailed, 140
  True, 139.
Iguanurus, 142.
Iguanidæ, 128.
Iguanodons, 37.
Ilysia, 195
Ilysiidæ, 195.
Ischnacanthus, 548.
Isospondyli, 475.

Jacares, 16
Jacuaru, 154.
Jararaca, 248.

Knerria, 468.
Kneriidæ, 468.
Knife Jawed Fishes, 349.
Kreuzotter, 230.

Labaria, 248.
Labridæ, 418, 419.
Labrus, 419.
Labyrinth-Gilled Fishes, 409.
Labyrinthodontia, 311
Lacerta, 159
Lacertidæ, 158.
Lacertilia, 104.
Lachesis, 243.
Læmargus, 334.
Lamna, 526.
Lamnidæ, 525.
Lampreys, 549, 550.
Lampris, 368.
Lancelets, 558.
Lariosaur, 103.
Larvacea, 572.
Lates, 340.
Latilidæ, 375.
Latilus, 375.
Latris, 351.
Latrunculus, 389.
Leathery Turtles, 86.
Lepadogaster, 407.
Lepidocottus, 381.
Lepidopus, 360.
Lepidosiren, 328.
Lepidosirenidæ, 326.
Lepidosteidæ, 506.
Lepidosteus, 507.
Lepidotus, 510.
Leptocardii, 558.
Leptodactylidæ, 273.
Leptodactylus, 276
Leptolepis, 491.
Leptoscopus, 375.
Leucaspius, 466.
Leuciscus, 459.
Lialis, 116.
Liasis, 186
Lichanura, 195.
Light Fish, 482.
Ling, 436
Liodesmus, 509.
Liodon, 249.
Lizards, 104.
  Agamoid, 107
  Anolis, 130
  Australian Frilled, 122.
  Beaked, 252.
  Bronze, 170.
  Ceylon Horned, 120.
  Flying, 118.
  Fringe-Toed, 166.
  Galapagos, 135, 137
  Girdled, 143.
  Greaved, 153.
  Green, 160.
  Horned, 142.
  Keeled, 165.
  Long-Necked, 249.
  Moloch, 127.
  Oriental Tree, 119.
  Pearly, 159.
  Poisonous, 148.
  Ridge headed, 134.
  Sail-Tailed, 123.
  Scale-Footed, 116.
  Sea, 135.
  Snake-Eyed, 168.
  Snake-Like, 145.
  Stilted, 134.
  Stump-Tailed, 167.
  Thorny-Tailed, 124, 127.
  True, 158.
  Viviparous, 162.
  Wall, 163.
Loaches, 466.
  African, 468.
Lobe-Finned Sharks, 546.
Loggerhead, 83.
Long-Finned Herring, 485.
Long-Fins, 351.
Long-Tails, 439.
Lophiidæ, 379.
Lophius, 379.
Lophobranchii, 423.
Lopholatilus, 375.
Lophotes, 414.
Lophotidæ, 414.
Lophurus, 123.
Loricaria, 455.
Lota, 435.
Loxocemus, 186.
Lucifuga, 437.
Luciocephalidæ, 409.
Luciocephalus, 414.
Lucioperca, 336.
Lump-Suckers, 386.
Lung-Fishes, 315, 326.
Luth, 86.
Lycodes, 431.
Lycodidæ, 430.
Lytoloma, 86.

Mackerels, 369.
Macroclemmys, 80.
Macrones, 455.
Macruridæ, 439.
Macrurus, 439.
Mailed-Tube-Mouths, 423.
Malacanthidæ, 376.
Malacanthus, 376.

Malacoclemmys, 72.
Malacosteus, 484.
Malapterurus, 455.
Mantella, 271.
Many-Rayed Salmon, 502.
Marane, 504, 505.
Marsipobranchii, 550.
Mastodonsaurus, 313.
Matamata, 90.
Meagres, 357.
Megalobatrachus, 302.
Megalosaurus, 35.
Megalurus, 509.
Melamphaes, 354.
Mene, 369.
Merluccius, 435.
Metoposaurus, 313.
Metriorhynchus, 32.
Microcosmus, 565.
Minnow, 461.
Miolania, 97.
Miolaniidæ, 97.
Misgurnus, 467.
Molge, 294.
Moloch, 127.
Molva, 436.
Monacanthus, 427.
Monitors, 149.
Monk-Fish, 535.
Monocirrhus, 352.
Monopterus, 451.
Moon-Eye, 479.
Mordacia, 553.
Morelia, 184.
Morenia, 74.
Mormyridæ, 474.
Mormyrus, 474.
Morone, 339.
Mosasaurus, 249.
Mud-Fish, 328.
Mud-Skippers, 389.
Mugil, 399.
Mugilidæ, 397.
Mullets, 345, 399.
  Grey, 399.
  Red, 345.
Mullidæ. 345.
Mullus, 345.
Muræna, 445.
Murænidæ, 445.
Mustelus, 524.
Myliobatidæ, 543.
Myliobatis, 543.
Myriacanthidæ, 332.
Myripristis, 354.
Myxine, 554.
Myxinidæ, 554.

Naia, 222
Nandidæ, 352.
Nandus, 352.
Nardoa, 186.
Naucrates, 365.
Nectes, 277.
Nectophryne, 277.
Necturus, 308
Nemachilus, 467.
Nematognathi, 452.
Nemichthys, 450.
Nerophis, 425.
Newts, 289, 295.
  Alpine, 296.
Newts—*continued.*
  Banded, 297.
  Common, 296.
  Crested, 295.
  Marbled, 296.
  Waltl's, 297.
  Webbed, 296.
Nicoria, 64.
Nomeidæ, 369.
Nomeus, 369.
Notacanthidæ, 417.
Notacanthus, 417.
Nothopsis, 199.
Notidanus, 532.
Notidanidæ, 532.
Notogoneus, 481.
Notopteridæ, 475.
Notopterus, 475.
Notothenia, 376.
Nototrema, 282.

Oblique-Spined Blenny, 395.
Ocadia, 74.
Oil-Fish, 396.
Olm, 307.
Oncorhynchus, 502.
Onychodactylus, 302
Ophichthys, 445, 449.
Ophidia, 174.
Ophidiidæ, 437.
Ophidium, 438.
Ophiocephalidæ, 408.
Ophiocephalus, 408.
Ophisaurus, 146.
Opisthoglypha, 198.
Ornithosauria, 39.
Orodus, 532.
Orthagoriscus, 430.
Osmerus, 503.
Osphromenus, 412.
Osteoglossidæ, 477.
Osteoglossum, 478.
Osteolæmus, 20.
Ostracion, 428.
Ostracophori, 555.
Oxybelis, 218.
Oxyglossus, 269.

Pachytriton, 299.
Pagellus, 346.
Pagrus, 348.
Palæobatrachidæ, 284.
Palæobatrachus, 284.
Palæohatteria, 254.
Palæoniscus, 517.
Palæophis, 195
Palæorhynchidæ, 362.
Palæorhynchus, 362.
Palæosiren, 313.
Palæospondylus, 554.
Pantodon, 480.
Pantodontidæ, 479.
Paradise-Fish, 411.
Paraperca, 336.
Parasitic-Fish, 438.
Pariasaurians, 255.
Parrot-Wrasses, 421.
Pegasus 386.
Pelagosaurus, 32.
Pelecus, 466.
Pelamys, 371.
Pelobates, 283.
Pelobatidæ, 283.
Pelochelys, 100.
Pelodytes, 284.
Pelomedusa, 97.
Pelomedusidæ, 88, 94.
Pelor, 351.
Pelorosaurus, 35.
Pelosaurus, 313.
Pempheris, 355.
Perca, 335.
Percarina, 337.
Perch,
  African, 340.
  Oriental, 340.
  Sea, 339.
  South American, 338.
Perch Tribe, 335.
Percichthys, 338.
Percidæ, 335.
Perciformes, 335.
Periophthalmus, 389
Peristethus, 385.
Petalopteryx, 384.
Petalodontidæ, 535.
Petalodus, 535.
Petromyzidæ, 551.
Petromyzon, 551.
Phallusia, 565.
Philodryas, 217.
Phosphorescent Fishes, 482.
Photichthys, 182.
Phrynocephalus, 122.
Phrynosoma 142.
Phyllodus, 419.
Phyllopteryx, 426.
Physoclysti, 334.
Physostomi, 441.
Pike, 473.
Pike-Head, 414.
Pike-Perches, 336.
Pilchard, 489.
Pilot-Fish, 365.
Pimelodus, 451.
Pinguipes, 376.
Pipa, 286.
Pipidæ, 287.
Pipe-Fishes, 424.
Plagyodus, 482.
Plaice, 443.
Platax, 366.
Platemys, 93.
Platurus, 227.
Platysomatidæ, 517.
Platysomus, 517.
Platysternidæ, 75.
Platysternum, 75.
Plectospondyli, 456.
Plectognathi, 423, 427.
Plesiochelyidæ, 97.
Plesiochelys, 97.
Plesiops, 352.
Plesiosauridæ, 102.
Plesiosaurus, 102.
Plethodon, 302
Pleuracanthus, 546.
Pleurodira, 88.
Pleuronectes, 439, 443.
Pleuronectidæ, 439.
Pleurosternum, 98.
Pliosaurus, 103.
Podocnemis, 93.
Podocys, 340.

Pogonias, 356.
Pollan, 504.
Polyacanthus, 411.
Polycentridæ, 352.
Polycentrus, 352.
Polyclinidæ, 568.
Polynemidæ, 355.
Polynemus, 356.
Polyodon, 513.
Polyodontidæ, 513.
Polypedates, 270.
Polyprion, 340.
Polypteridæ, 517.
Polypterus, 517.
Pomacentridæ, 418.
Pomacentrus, 418.
Porbeagle, 525, 526.
Portheus, 486.
Port Jackson Shark, 530.
Powan, 504.
Power-Cod, 431.
Primeval Salamanders, 311.
Priacanthus, 363.
Pristidæ, 535.
Pristiophoridæ, 535.
Pristiophorus, 536.
Pristipoma, 340.
Pristis, 536.
Propseudopus, 147.
Proteidæ, 306.
Proteus, 307.
Proteroglypha, 198, 218.
Protorosaurus, 254.
Protochordata, 549, 550, 558.
Protopterus, 329.
Protosphargis, 88.
Protostega, 88.
Prototroctes, 492.
Protriton, 314.
Psammodromus, 165.
Psammoperca, 340.
Psephophorus, 88.
Psephurus, 513.
Psettodes, 412.
Psettus, 366.
Pseudechis, 225.
Pseudobranchus, 309.
Pseudochromis, 376.
Pteraspis, 555.
Pterichthys, 556.
Pterodactyles, 39.
Pterodactylus, 41.
Pterois, 351.
Pteroplatea, 545.
Ptyas, 208.
Ptychozoon, 114.
Ptyodactylus, 112.
Pyledus, 382.
Pygopodidæ, 116
Pygopus, 117.
Pyrosoma, 569.
Pyrosomatidæ, 569.
Python, 182.
Pythoninæ, 139.
Pythonomorpha, 249.
Pythons, 181.
    Amethystine, 184.
    Anchieta's, 186.
    Indian, 182, 186.
    Reticulated, 184.
    Royal, 186.
    Timor, 184.
Pythons—*continued*.
    True, 182.
    West African, 182, 185.
Pyxis, 84.

Raia, 541.
Raiidæ, 541.
Raj Samp, 227.
Rana, 265.
Ranidæ, 265.
Ranodon, 302.
Rapfen, 461.
Rattle-Snakes, 238.
    Common, 239.
    Diamond, 240.
    South American, 240.
Rays, 520.
    Beaked, 538.
    Eagle, 548.
    Electric, 542.
    Halavi, 539.
    Sting, 545.
    True, 541.
Red Mullets, 345.
Reed-Fish, 517.
Regalecus, 416.
Reptiles, 1.
Rhabdopleura, 574.
Rhacolepis, 491.
Rhacophorus, 270.
Rhampholeon, 172.
Rhamphorhynchus, 41.
Rhamphosuchus, 31.
Rhinechis, 212.
Rhinemys, 93.
Rhinobatidæ, 538.
Rhinobatis, 539.
Rhinodon, 527.
Rhinodontidæ, 527.
Rhinophrynus, 277.
Rhinoptera, 544.
Rhipidistia, 518.
Rhiptoglossa, 171.
Rhodeus, 462.
Rhynchobatus, 540.
Rhynchobdella, 396.
Rhynchobdellidæ, 395.
Rhynchocephalia, 252.
Rhynchosaurus, 254.
Rhynchosuchus, 29.
Ribbon-Fish, 414, 415.
Rita, 455.
Roach, 479.
Rockling, 436.
Ruffes, 337.

Saccopharynx, 449.
Saccostomus, 239.
Saibling, 501.
Salamanders, 289, 291.
    Alpine, 293.
    Black, 293.
    Eel-Like, 305.
    Fish-Like, 302.
    Giant, 302.
    Gilled, 306.
    Mississippi, 304.
    Primeval, 310.
    Siren, 309.
    Spanish, 294.
    Spectacled, 298.
    Spotted, 291.
Salamanders—*continued*.
    Three-Toed, 305.
    Two-Legged, 308.
    Typical, 291.
Salamandra, 291.
Salamandridæ, 291.
Salamandrella, 302.
Salamandrina, 298.
Salamandrinæ, 291.
Salmo, 494.
Salmon, 493, 495.
    Beaked, 480.
Salmonidæ, 493.
Salpa, 572.
Salpidæ, 570.
Sand Eels, 437, 438.
Sand-Smelts, 397.
Sardine, 489.
Sargus, 347.
Saurocephalidæ, 486.
Saurocephalus, 486.
Saurodonts, 486.
Sauropterygia, 101.
Saury, 401.
Saw-Fishes, 535.
Scabbard-Fish, 360.
Scaled Reptiles, 104.
Scaly-Finned Fishes, 343.
Scaphiopus, 283.
Scaphirhynchus, 516.
Scarus, 421.
Scatharus, 347.
Scatophagus, 341.
Scheltopusiks, 148.
Schnæpel, 504.
Sciæna, 357.
Sciænidæ, 356.
Scincidæ, 168.
Scincus, 169.
Scomber, 369.
Scombridæ, 369.
Scombresocidæ, 400.
Scombresox, 401.
Scopelidæ, 481.
Scopelus, 481.
Scorpæna, 351.
Scorpænidæ, 351.
Scorpænoids, 351.
Scylliidæ, 529.
Scyllium, 530.
Sea-Bats, 366.
Sea-Breams, 346.
Sea-Horses, 424.
Sea-Perch, 339.
Sea-Snakes, 226.
Sea-Squirts, 561.
Sebastes, 351.
Selachoidei, 515.
Semivertebrates, 549, 550.
Serpent-Eels, 449.
Serpent-Heads, 408.
Serranidæ, 338.
Serranus, 339.
Serrasalmo, 468.
Shad, 489.
Sharks, 520.
    Basking, 527.
    Blue, 522, 523.
    Comb-Toothed, 535.
    Fold-Finned, 540.
    Fox, 526.
    Frill-Gilled, 536.